LINEAR PROGRAMMING AND GENETIC ALGORITHM BASED OPTIMIZATION FOR THE WEIGHTING SCHEME OF A VALUE FOCUSED THINKING HIERARCHY

THESIS

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Abstract

Deriving weights for a Value Focused Thinking (VFT) hierarchy demands considerable time and input from Decision Makers (DM) and Subject Matter Experts (SME). Often, the DMs and SMEs are the leaders of companies and organizations, and this required time is unrealistic with their schedules. In these situations, as well as scenarios where the are no available DMs / SMEs, conventional means of weighting a VFT hierarchy are impossible, and any VFT analysis is halted. When historical data exists on evaluation measures and performance of alternatives, linear programming and genetic algorithm based optimization may be used to derive historically optimal weights for a hierarchy. Analysis may then be done to determine the utility of transposing these weights into a hierarchy to evaluate a current list of alternatives. This type of analysis is also useful in "first cut" weighting of a hierarchy, and therefore reduces the time demands for DMs/SMEs to complete the weighting process. This methodology can provide insight into any situation where historical information exists on ordinally ranked, competing alternatives.

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Chapter 1. Introduction

> "If a man will begin with certainties he will end with doubts, but if he will be content to begin with doubts he shall end in certainties" (Francis Bacon)

1.0 Background

> Decision analysis provides effective methods for organizing a complex problem into a structure that can be analyzed. In particular, elements of a decision's structure include the possible courses of action, the possible outcomes that could result, the likelihood of those outcomes, and the eventual consequences (e.g., costs and benefits) to be derived from the different outcomes. (Clemen 1996)

Decision analysis' influence has been rapidly spreading as decision-makers are looking for a better way to analyze what is truly important in a decision. Although its origins date back to the mid-sixties, when Ronald Howard defined the field while he was an Associate Professor at MIT, the popularity for decision analysis has mainly grown over recent years. Brainstorming and other conventional methods of attacking hard decisions make it nearly impossible to arrive at a quality decision without forgetting major aspects of the objective, not considering highly qualified alternatives, and allowing personal bias to completely dominate the decision. The educated, formal logic of decision analysis appeals to the decision-maker (DM) for its thoroughness and strategic logic (Clemen 1996). It has been used by countless companies to better their ways of business, and done so successfully in many fields of study (Decision 1999).

Value focused thinking (VFT), a subset of decision analysis, deals with multiple-objective decision-making. The objectives are competing and require consideration of tradeoffs among these objectives (Kirkwood 1997). These multiple, competing objectives are the outline for what a decision-maker "values" in their decision. The main objectives that go into the decision are broken down into sub-objectives, and those sub-objectives are further broken into their own sub-objectives, until the sub-objectives can be quantified into "measures" which directly or indirectly give a rating to each value. VFT is implemented using a ten step iterative process, which will be discussed in depth within chapter two.

VFT's goal is to uncover what is truly valued in a fundamental objective (issue of importance). After the values are broken down in a hierarchical fashion, the different facets of this decision are "weighted" by relative importance. Values with higher weights often drive the decision, and all values are tradeoffs in that the sum of the weights under each value equals one. The completed VFT process allows one to rank alternatives depending on how high of a score they receive by the hierarchy.

Assigning weights to the different values under a hierarchy is often a topic of concern (Kirkwood 1997). Group discussions, meetings with company leaders, surveys of employees, etc, are examples of ways to determine a hierarchy's weights. This input from professionals in the field of study is a critical step in determining the weights of the hierarchy. They are considered the decision makers (DM) and/or subject matter experts (SME) in the area of interest. These professionals are the people that do the work, day in and day out, and know the system the best. Without their input, conventional VFT weighting techniques are simply not possible. Being without their input is not

uncommon. In the military, getting hours of a General's time is highly unlikely. If a hierarchy is built with the objective of determining what an enemy or competitor values, there is little chance they will weight the hierarchy. Historically, this type of roadblock ended VFT possibilities.

In cases where historical data is readily available, statistical analysis and optimization may provide an acceptable means of determining the weights when professionals are unavailable. With a strong hierarchy based on measures that may be determined through the historical data, and knowledge of past performance of competing alternatives, one may solve for the weights of the hierarchy which best match up with the known past performance. The derived weights give a projected ranking, which if optimal, will mirror the true historical rankings. Once these weights are determined, analysis may be done on current alternatives, by projecting the previous weights into the future (current time period).

The optimization needed to solve for these weights is based on minimizing an error function that is subject to constraints that all sub-categorical weights for the values and measures in the hierarchy, sum to one. The error function may vary widely depending on the desired outcome, but it is based on the difference between the known ranking of the alternatives and the projected rankings of these alternatives after the weights for the hierarchy are determined.

The hybrid Evolutionary/Classical Solver within Premium Solver® is used to optimize the weighting scheme of the hierarchy. "The hybrid Evolutionary/Classical Solver uses genetic algorithm methods such as mutation, crossover, selection and constraint repair, but also uses deterministic, gradient-free direct search methods,

classical gradient-based quasi-Newton methods, and even the Simplex method for linear subsets of the constraints" (Premium 1).

1.1 Problem Statement

The purpose of this thesis is to provide a methodology to weight a Value Focused Thinking hierarchy when input from professionals is unavailable. Excel's Evolutionary/Classical Solver® is used to optimize the weights of a hierarchy by minimizing an error function that is based on matching historical rankings of competing alternatives.

1.2 Research Objective

This thesis integrates optimization with value focused thinking to solve for the weights of a VFT hierarchy. If historical data and performance are available, and what is truly valued in a fundamental objective is consistent, the knowledge of the past can be projected into the future through solving for the weights of the hierarchy. By this means of weighting being successful, the benefits of the Value Focused Thinking process increases dramatically. The VFT process no longer ends when the SMEs or DMs are unable to weight the hierarchy. This process may also provide useful "first-cut" insight into the weighting, even if the SMEs and/or DMs are available, or in a situation where one attempts to gain insight into an "enemy's" process. The time constraints on these individuals can be greatly reduced by using this methodology to solve for the weights, thus providing a superior starting point for the DM's/SME's input.

1.3 Methodology

The first step of this research is to select an example to explore the weighting technique used to estimate the weights during the use of Value Focused Thinking. This example must contain the necessary components in order for this weighting scheme to be possible:

1: Enough historical data/information must exist in order to build a hierarchy with the measures of that hierarchy being based upon this data/information.

2: This data/information must be available on multiple competing “alternatives”.

3: In relation to one another, the historical performance of these alternatives must be known.

Once this example is selected, a hierarchy must be built around the fundamental objective. Next, an error function must be formulated with the desired goals of the optimization. The weights of the hierarchy are determined through optimization of the historical data inputs for the measures of the hierarchy. The weights may be solved for different time periods and durations. With a best-suited weighting scheme for the current period, each alternative will be scored under this hierarchy, and the resulting “choice” will be known. The weighting of the value focused thinking process is now complete, and done without any input from a decision maker or subject matter expert.

1.4 Thesis Outline

The literature review will look at relevant literature that provides a necessary background to understand the methodology of this thesis. Through examples, chapter three will illustrate the methodology behind using optimization to solve for the weights of

a VFT hierarchy. This will include a mathematical formulation for the optimization, and a 7-step process that walks through the major aspects of this methodology. Chapter four will provide a real world example of using the proposed methodology. The example will look at a hierarchy with the fundamental objective of "what does one value in a military construction (MILCON) project." The weights of this hierarchy will be optimized using historical data, and the resulting weights will provide insight into what the decision-makers historically valued. Finally chapter five will summarize the strengths, weaknesses, and insight gained from this thesis. It will also list possible areas for future study on this topic.

Chapter 2. Literature Review

2.0 Introduction

The purpose of this chapter is to review relevant literature and provide a fundamental background in the areas of Decision Analysis, Value Focused Thinking, and Linear Programming. This chapter will begin with an in-depth discussion on Decision Analysis, followed by an introduction into a subset of Decision Analysis, Value Focused Thinking, and finally give a short background into one of the most popular optimization methods, Linear Programming. Through studying this chapter, the reader should have an adequate background to understand the methodology introduced in chapter 3.

2.1 Decision Analysis

> What is a decision? The one essential element of a decision is the existence of alternatives. That is, you must have choice to make between at least two different things, only one of which you can select. If you don't have alternatives, then you may have a problem, but it isn't a decision problem. (Of course, some of the most vexing decisions are those where you do not seem to have any good alternatives.) (Kirkwood 1997)

The field of decision analysis (DA) was defined by Ronald Howard in 1964 while he was Associate Professor of Electrical Engineering, Associate Professor of Industrial Management, and Associate Director of the Operations Research Center at MIT (Howard). He joined the Stanford Faculty in 1965 and has been teaching decision analysis thereafter. Since 1964, decision analysis has been a rapidly growing field. Many consulting companies are using a variation of the process, and numerous Fortune 500 companies are currently setting up their own decision analysis consulting groups (Decision Education 2000). Numerous professional societies associated with decision

analysis have arisen, such as the Decision Analysis Affinity Group, a society in which over fifty major companies participate, and INFORMS, a predominantly operations research society.

Decision analysis is a set of quantitative methods for analyzing decisions based on the axioms of consistent choice (Keefer 2000). It is a structured and strategic way of thinking about how the action taken in the current decision would lead to a result (Spradlin 1997). DA helps to eliminate much of the bias that often hinders decision makers. Clemen explains that there are four basic sources of difficulty, necessitating the use of decision analysis to simplify the decision-making process (2). The first source of difficulty is complexity. Often times there are many different facets to the decision at hand. Keeping track of these issues and accurately defending each of their positions in ones mind is nearly impossible. Inherent uncertainty in the situation is the second source of difficulty.

> For example, imagine a firm trying to decide whether to introduce a new product. The size of the market, the market price, eventual competition, and manufacturing and distribution costs all may be uncertain to some extent, and all have some impact on the firm's eventual payoff. A decision-analysis approach can help in identifying important sources of uncertainty and representing that uncertainty in a systematic and useful way. (Clemen 1996)

The third source of difficulty deals with multiple objectives in which progress in one direction may impede progress in another. This is where a decision maker is forced to trade off a benefit in one area with a cost in another. Clemen's final source of difficulty arises if different perspectives lead to different conclusions, or even if a single perspective with slight changes to inputs, leads to a different choice.

> This source of difficulty is particularly pertinent when more than one person is involved in making the decision. Different individuals may look at the problem from different perspectives, or they may disagree on the uncertainty or value of the various outcomes. The use of decision-analysis framework and tools can help sort through and resolve these differences whether the decision maker is an individual or a group of stakeholders with diverse opinions. (Clemen 1996)

Clemen breaks down the decision analysis process into the following flowchart:

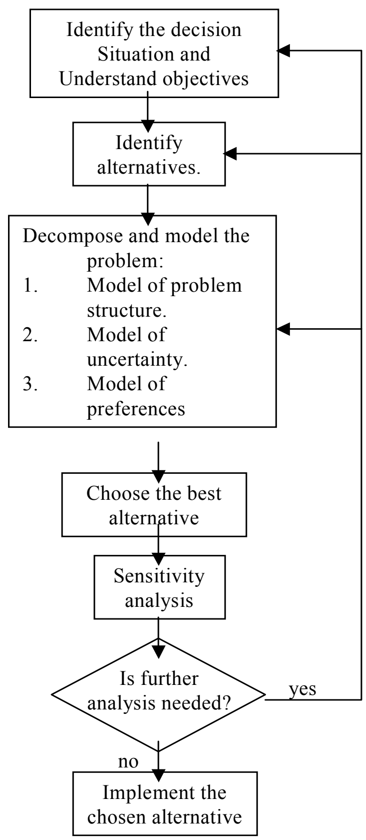


Figure 2.1: Decision Analysis Process Flowchart

Although this is Clemen's DA flowchart, it holds close to the form of many author's stepwise progression through the decision analysis process. For this reason, his flowchart will be used to depict the DA process in general.

Identify the decision situation and understand objectives:

The first step of the decision analysis process, identifying the decision situation and understanding the objectives, is a critical process. “Although we usually do not have trouble finding decisions to make or problems to solve, we do sometimes have trouble identifying the exact problem, and thus we sometimes treat the wrong problem” (Clemen 1996). Understanding the objectives is important in that the objectives need to be on the front of the decision makers mind in order to keep them from straying off what is important. “A primary difficulty in many decisions is figuring out what things are important in evaluating the consequences of a decision” (Kirkwood 1997).

Identify alternatives:

Identifying alternatives is the next step in the decision analysis process in which alternatives that are intuitively obvious, and those less obvious alternatives which meet the criteria of the fundamental objective, make up a list of possible alternatives. Kirkwood noted the complexity of this task when he stated “Another difficulty in decision making is determining the relative importance of different aspects of the consequences.” (2). Careful examination of the objectives should lead to alternatives that would not have been otherwise considered. Although the number of alternatives must be limited to a reasonable number, it is important to have a diverse list of objectives that stretch over broad horizons. Kirkwood warns that “Many people do no cast their nets wide enough when they consider alternatives.” (Kirkwood 1997). He also notes that the complexity of many modern management decisions is at fault for many of the alternatives not being considered. Kirkwood finally warns against relying solely on specialists, for they often analyze options they know how to solve, rather than the preferable ones.

Decompose and model the problem / Choosing the best alternative:

Decomposing and modeling the problem, along with choosing the best alternative, is what Clemen and many other authors classify as the "modeling and solution" of the problem (7). These two steps are the heart of the decision analysis process, and where the majority of time and effort is spent. Clemen breaks down the "Decompose and model the problem" into modeling of the problem structure, modeling of uncertainty, and modeling of preferences. The goal of the decomposition of the problem is to simplify the structures and measure value and uncertainty. By breaking down the problem into more definable elements, the decision maker may in turn gain more insight into the individual elements and better model each facet of the overall problem. Decision trees coupled with probabilistic uncertainty models are the foundation for the "modeling" process as a whole. In value focused thinking, which will later be explained at length, a hierarchical model is introduced in which multiple competing objectives are simultaneously considered. The accuracy of ones model directly reflect the quality of insight obtained through the decision analysis process.

Sensitivity Analysis:

Sensitivity analysis is the arena in which one can check the robustness of their model. It can be used to determine the impact on the ranking of alternatives, given some change in various model assumptions (Kirkwood 1997). If the optimal decision changes with the minor altering of the model, the decision is considered sensitive and the decision maker is encouraged to reconsider those particular aspects of the model (Clemen 1996). As shown in Clemen's flowchart, sensitivity analysis can send one back to any of the first

three steps of the DA process, including defining the objectives. It is very common to follow this cyclic pattern Clemen's flow chart depicts until the objectives are clearly defined, most all alternatives are considered, and models are refined. This is the common process of decision analysis.

2.2 Value Focused Thinking

Developed by Keeney in 1992, Value Focused Thinking (VFT) is decision analysis that deals with multi-objective decision-making (Keeney 1998). VFT is a great tool that has been successfully implemented in a vast number of professional arenas and studies, including the Operational Analysis of Air Force 2025 (Jackson 1996), deciding new policies (Keeney 1998), selecting and implementing security procedures for transporting nuclear waste (Keeney 1998), and selecting construction sites for critical installations (Keeney 1993). As Ralph Keeney explains, VFT consists of two activities: deciding what you want and figuring out how to get it (4). This way of thinking, Keeney claims, gets one closer to their goal than conventional alternative focused thinking in terms of "here are my options, which is the best." Keeney illustrates many of VFT's benefits with the following diagram:

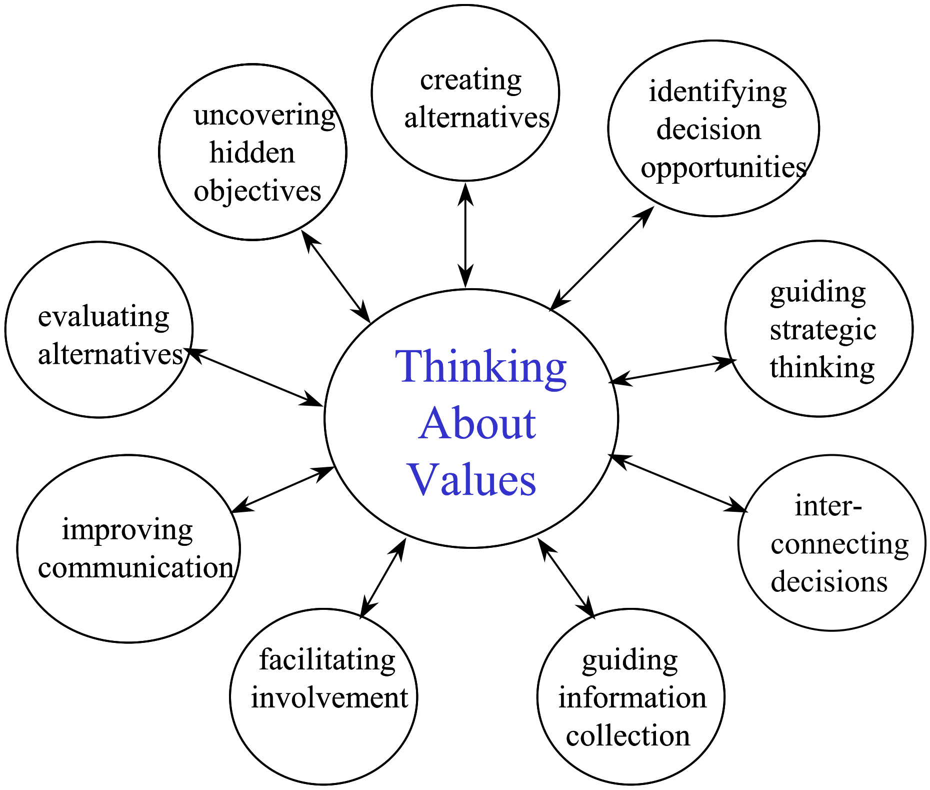


Figure 2.2: Benefits of Value Focused Thinking

2.2.1 The Ten Step Process

Chambal uses a 10-step VFT flowchart, similar to Clemen's DA flowchart, which methodically outlines the value focused thinking process (Class 2002):

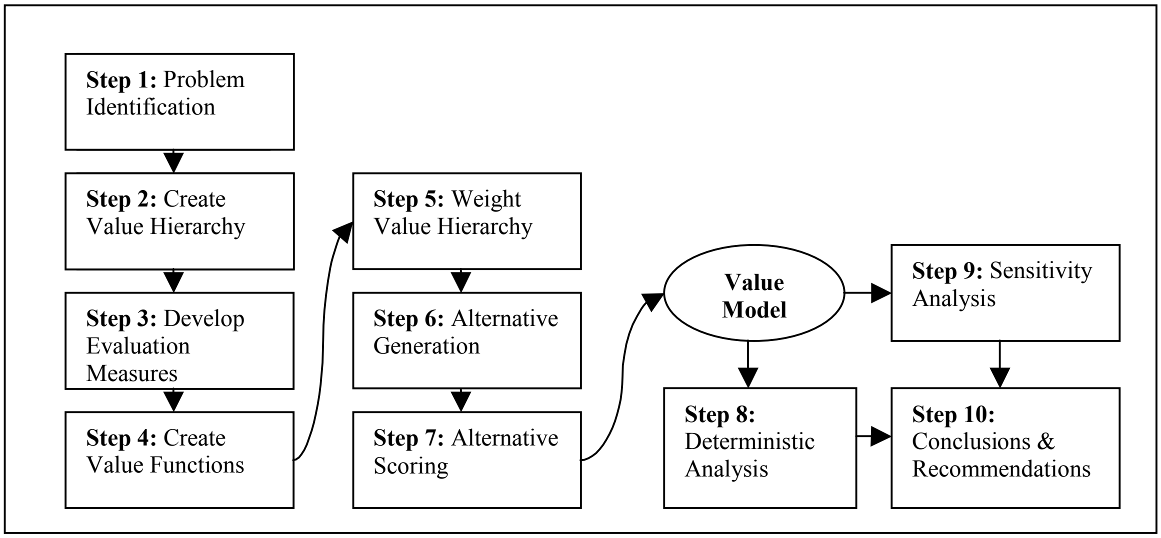


Figure 2.3: The Ten Step Process

Although this ten-step process appears sequential in nature, it is important to note that it is truly iterative. Keep in mind that many iterations of the following "steps", may be taken before the process is complete.

Step 1: Problem Identification

Problem identification is the step in the VFT process where the groundwork is laid for the rest of the analysis. This is where the brainstorming of the actual problem takes place, and where the question "what is our ultimate goal", is answered. This is also the milestone where the fundamental objective is solidified. Keeney defines an objective as "…something that one desires to achieve" and characterizes it by three features: a decision context, an object, and a direction of preference (Keeney 1992). He also stresses that:

> Values of decision-makers are made explicit with objectives. Hence, the set of objectives developed for a decision frame is absolutely critical. The fundamental objectives are the basis for any interest in the decision being

> considered. There objectives qualitatively state all the is of concern in the decision context. They also provide guidance for action and the foundation for any quantitative modeling or analyses that may follow this qualitative articulation of values. (Keeney 1992)

For the illustrative purposes of this chapter, the problem of "Where should I go to college" will be examined. It should be noted that this example's purpose is to give a basic understanding, and the rigor of this example is far less than would be taken in a true VFT process.

Step 2: Create Value Hierarchy

Creating the value hierarchy is likely the most difficult step in the VFT process. Kirkwood describes a value hierarchy as a value structure with a hierarchical or "treelike" structure (Kirkwood 1997). It is the model that breaks down a fundamental objective into smaller sub-components, and finally into measurable units. The reason why this step is so difficult is because of the complexity of determining "what you truly value." An example of this would be the question of "where should I go to college". The following chart is the beginning of a possible hierarchy built for this fundamental objective:

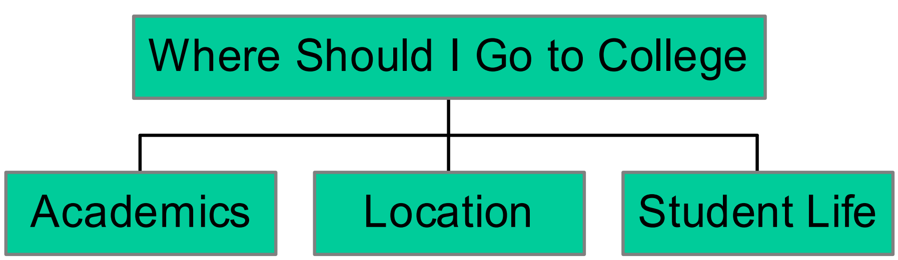


Figure 2.4: College Hierarchy

In the example, the three pillars determining "where should I go to college" are academics, location, and student life. These values could be broken down further, for example "what do I value in academics, etc…", or measures could be determined to rate the individual performance of a college under each of the values. It is critically important to ensure that values under a fundamental objective are independent. That is, making sure that the preference for the level of one evaluation measure does not depend on the level of the other evaluation measure (Kirkwood 1997). Kirkwood lists independence along with completeness, nonredundancy, operability, and small size, all as desirable properties of a value hierarchy (16). While building the value hierarchy, the question of money typically arises. In many value hierarchies, such as the "where should I go to college" hierarchy, intuition suggests that the cost would play a major role. Money or cost, however, will not be included in the value hierarchy. It is recommended to leave money out of the hierarchy, and only use a benefit/cost ratio based on the overall benefit (Kirkwood 1997).

Step 3: Develop evaluation measures

An evaluation measure as explained by Kirkwood is:

> A measuring scale for the degree of attainment of an objective is an evaluation measure. Thus, "annual salary in dollars" might be the evaluation measure for the job seeker's objective of finding a higher salary. Other terms that are sometimes used for an evaluation measure of effectiveness, attribute, performance measure, or metric. (12)

Evaluation measures are how an individual alternative is scored on how well it meets a value. For example, the case of the college hierarchy may have three measures, one for each sub-objective:

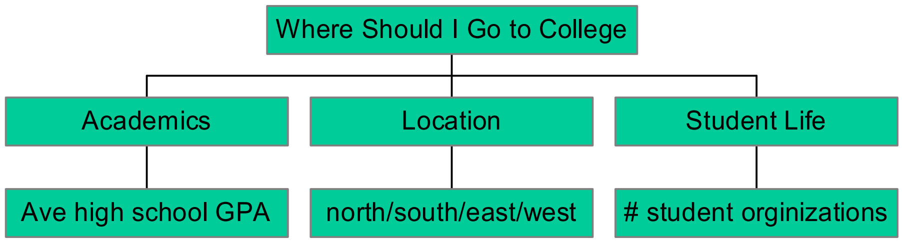


Figure 2.5: College Hierarchy with Measures

In the example, the quality of academics is "measured" by the average high school grade point average of the students attending the college. The quality of location is "measured" by whether the school is in the north, south, east, or west. Finally, student life would be "measured" by the number of student organizations present on the college campus. "Evaluation measure scales can be classified as either natural or constructed, and also either direct of proxy" (Kirkwood 1997). Therefore, the four types of measures are natural-direct, constructed-direct, natural-proxy, and constructed-proxy.

Kirkwood explains the different scales as:

Natural- In general use with a common interpretation by everyone

Constructed- Developed for a particular decision problem to measure the degree of attainment of an objective

Direct- Directly measures the degree of attainment of an objective

Proxy- Indirectly reflects the degree of attainment of its associated objective

Step 4: Create value functions

Single dimension value functions (SDVFs) are a way of placing all of the measures on a common scale, industry standard for which, is 0 to 1 (0 being worst, and 1

being best). SDVFs translate a score relative to the individual measure into this zero to one scale. To illustrate the most frequently used SDVFs, consider the example of "average high school GPA" measure under the college hierarchy:

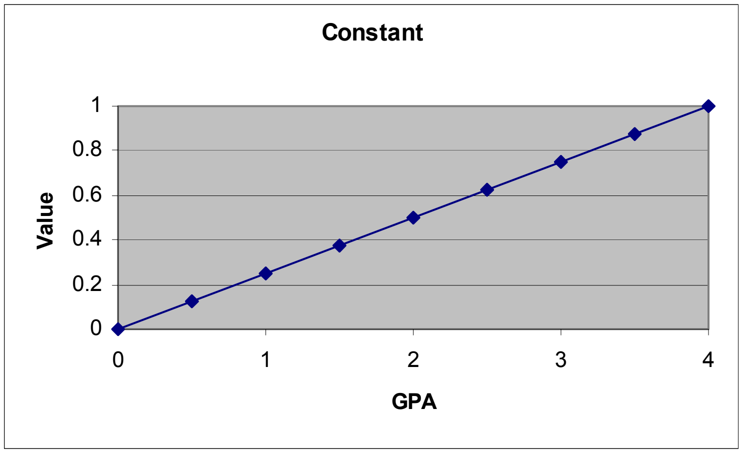


Figure 2.6: Constant returns to scale

As you can see from Figure 2.6, as in all the value functions, the higher the average high school GPA, the better. Because the function is linear, with each increment in the x-axis (GPA), the increase in value stays constant. This is called constant returns to scale.

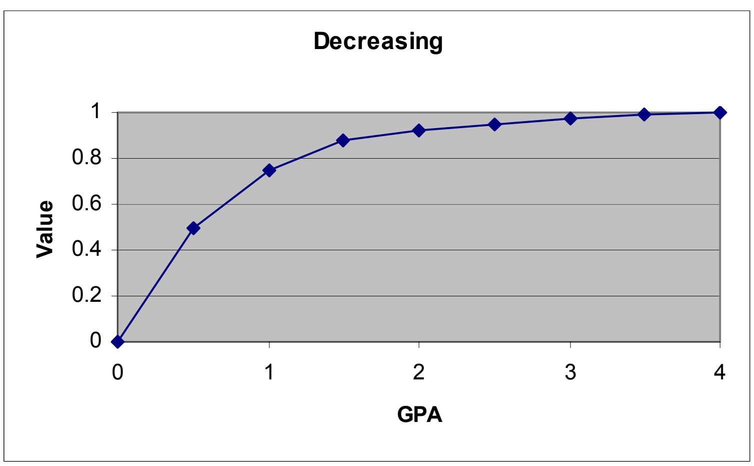


Figure 2.7: Decreasing returns to scale

The concave nature of figure 2.7 represents decreasing returns to scale. This is the situation where a lot of value is added early on for an increase in average GPA, however as GPA increases, the increase in value lessens.

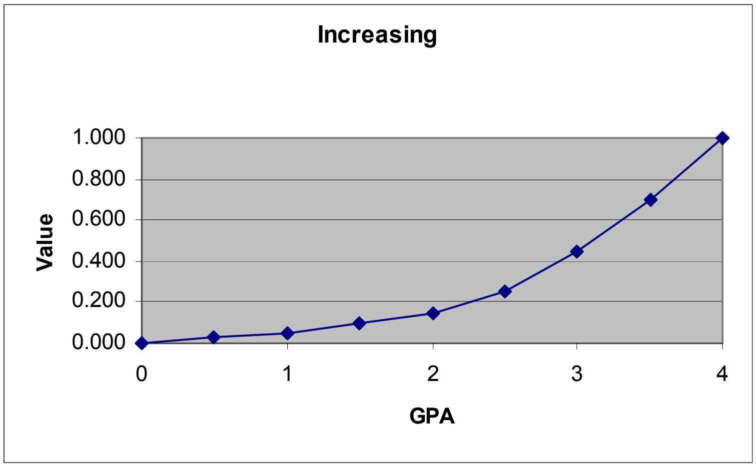


Figure 2.8: Increasing returns to scale

The convex nature of figure 2.8 represents increasing returns to scale. This is the scenario where less value is added early on for an increase in average GPA, however as GPA increases, the increase in value rises with each increment of the x-axis.

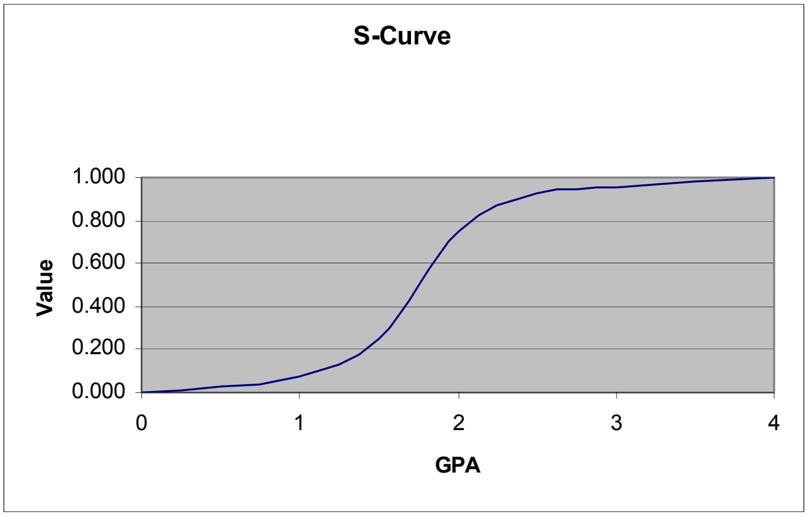


Figure 2.9: Other returns to scale, ie. S-curve

Other curves, such as the s-curve illustrated in figure 2.9, may also be used as single dimension value functions. The s-curve is ideal when little value is gained early on or late for per increase in GPA, however the most gain in value is found during some middle period. The value gained per increase in GPA slowly grows in early times, until some maximum slope is reached, then this delta gradually decreases for the remainder of the x-axis.

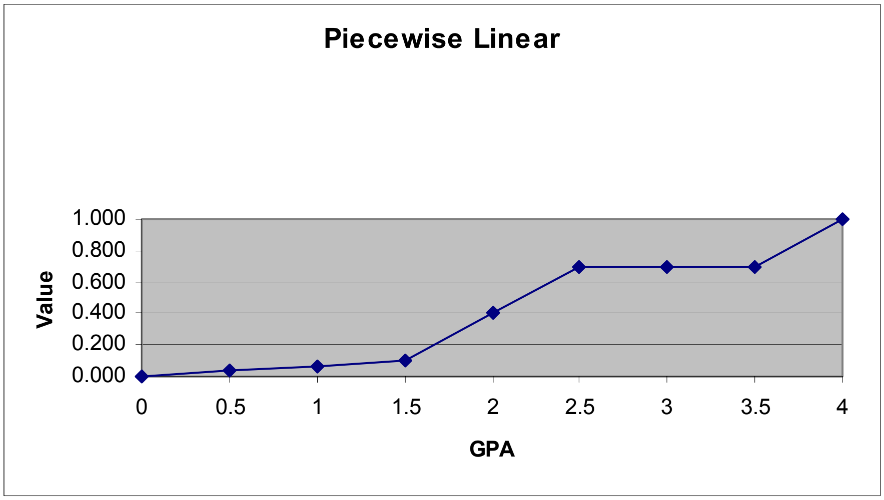


Figure 2.10: Piecewise linear single dimension value functions

Piecewise linear single dimension value functions have constant returns to scale within each region. These regions are discrete increments of the x-axis, where the slope differs from the surrounding periods. In the graph above, although constant in the individual intervals, the increase in value per increase in GPA is different from 0-1.5, as it is from 1.5-2.5, 2.5-3.5, and 3.5-4.

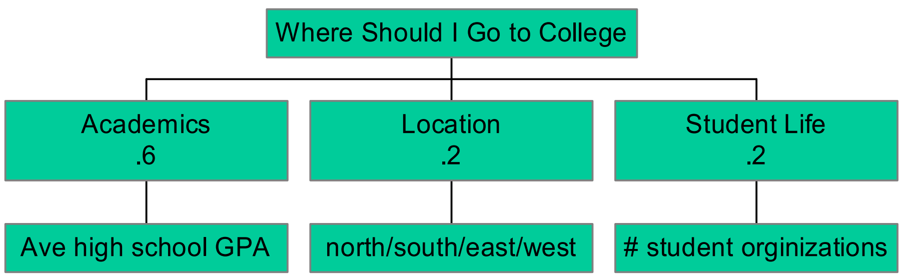
As is apparent from the previous examples, these single dimension value functions translate an abstract measurement, such as average high school GPA, into a quantifiable zero to one value score.

Step 5: Weight the value hierarchy

Weights provide tradeoffs between competing objectives.

> From these properties of the single dimensional value functions, it follows that the weight for an evaluation measure is equal to the increment in value that is received from moving the score on that evaluation measure from its least preferred level to its most preferred level. This property provides a basis for a procedure to determine the weights. (Kirkwood 1997)

There are multiple ways to weight a hierarchy, all based on preference. Kirkwood discusses “swing weighting”, others prefer a direct method, but all methods have the same goal of determining preference among competing objectives. The importance is in having a comfortable allocation of the weights across the values in the hierarchy. In the college hierarchy, possible weighting could be as follows:



In this example academics are most valued, therefore they are given a relatively high weight of .6, compared to the weights of .2 and .2 for location and student life respectively. The weighting of location and student life show that these are equally valued in deciding “where should I go to college.”

Step 6: Alternative generation

Alternative generation is very similar to the step in the general DA process where the goal is to get a wide variety of candidates to be evaluated by the hierarchy. Alternative generation is the step in the VFT process where all possible alternatives which meet the criteria of the fundamental objective need to be considered. From these

possibilities, a diverse list of alternatives needs to be selected. Careful examination of the objectives should lead to alternatives that would not have been otherwise considered. Although the number of alternatives must be limited to a reasonable number, it is important to have a diverse list of objectives that stretch over broad horizons. In the college example, it would be desirable to have schools from all over the country, with different levels of academics and student life (Harvard, University of Florida, Notre Dame, Air Force Academy, Berkeley, etc…).

Step 7: Alternative scoring

The process of scoring alternatives determines how an alternative scores on the "x-axis". The raw scores are found for each of the measures. For example, in the case of the college hierarchy, the average high school GPA of the Air Force Academy may be a 3.8. This is the score along the x-axis of the SDVF, for this particular measure. This process is done for every measure, for each of the alternatives

Steps 8: Deterministic Analysis

The step of deterministic analysis is where an alternate's overall value is calculated. The value of an alternative is calculated in the following manner:

$$v(x) = \sum_{i=1}^{n} w_i v_i (x_i)$$

$$\sum_{i=1}^{n} w_i = 1$$

$v(x) =$ The multiobjective value function

$v_i(x_i) =$ The single dimensional value function i

$w_i =$ The weight for evaluation measure i

Figure 2.11: The Value Function

In words, the multi-objective value function is equal to the sum of all "scored" single dimension value function values multiplied by their respective evaluation measure weight. These weights, w_i, are what capture the relative importance of an individual measure. Once all alternates receive an overall score, these scores may be compared to create a ranked list.

Steps 9: Sensitivity Analysis

This step is where the "what if" questions of the analysis are answered, and the sensitivity of the decision is determined. Determining the sensitivity involves manipulating weights to see where rankings change. If the outcome is not sensitive to change, weights and SDVFs may be moderately changed, without any change in the ranking of the top alternate. If the outcome is sensitive however, these slight changes affect this ranking, and the confidence in the top alternate lessens. This sensitivity analysis shows how truly close competing alternatives are.

Steps 10: Conclusions and Recommendations

This step provides insight and summarizes the findings through the ten-step VFT process. A final recommendation is made regarding the fundamental objective, keeping in mind the sensitivity and costs of this recommendation.

2.3 Problems Without a Decision Makers

It is not uncommon to be faced with a Value Focused Thinking problem in which no "decision maker(s)" are available for the weighting of the hierarchy. This is often a problem because either the decision makers are too busy, or they are simply unavailable to provide input. As mentioned earlier, this problem may also arise if the VFT process is attempting to gain insight into a competing organization or enemy. If the decision makers are not present, conventional means of weighting the hierarchy are eliminated.

The scenario is especially prevalent in the military. General officers' schedules rarely allow room for frequent meetings and discussions focused on providing feedback into "what they truly value" in a hierarchy. The available time may be limited, therefore any insight into a first cut of the weighting would greatly benefit the process. The General may be the only individual who can accurately weight the hierarchy, but a first cut will provide a starting point for solicitation These are the times, in the military as well as the civilian world, where another means of weighting the hierarchy must be explored.

2.4 Using Linear Programming to Select Appropriate Weights

This study proposes using linear programming as a solution to determining appropriate weights when decision makers are unavailable. If a past performance of alternatives is known and if any type of common rating criteria is available for the

alternatives, linear programming may be used to determine the weights. The derived weights will minimize the difference between the known and predicted rankings. This assumes that the past known rankings are available.

2.5 Linear Programming

George B. Dantzig is credited with the introduction of linear programming after his development of the simplex method in 1947 (Bazarraa xi). It was developed during and after World War II, due to the necessity for planning and coordination among various projects and the need for efficient utilization of scarce resources (Bazaraa vii). The modeling capabilities linear programming provides has made it a success in many fields of study.

> Since the development of the simplex method many people have contributed to the growth of linear programming by developing its mathematical theory, devising efficient computational methods and codes, exploring new algorithms and new applications, and by their use of linear programming as an aiding tool for solving more complex problems, for instance, discrete programs, nonlinear programs, combinatorial problems, stochastic programming problems, and problems of optimal control. (Bazarraa vii)

The development of linear programming has been ranked among the most important scientific advances of the mid-20th century (Hillier 25). The most often seen linear programming problem involves allocating limited resources among competing activities in an optimal way. This is optimizing a function, while satisfying linear constraints. In the following definitions, Bazarraa breaks linear programming down in a mathematical manner (2) (Bazarraa gives a minimization example, with ≥ constrains. Maximization problems, and both ≥ and ≤ constraints are also possible):

Consider the following linear programming problem:

Minimize $\quad z = c_1x_1 + c_2x_2 + \dots + c_nx_n$

Subject to:
$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n &\geq b_1 \\ a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n &\geq b_2 \\ &: \\ &: \\ a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n &\geq b_m \\ x_1, x_2, \dots, x_n &\geq 0 \end{aligned}$$

Here $c_1x_1 + c_2x_2 + \dots + c_nx_n$ is the objective function (or criterion function) to be minimized and will be denoted by z. The coefficients $c_1, c_2, \dots, c_n$ are the (known) cost coefficients and $x_1, x_2, \dots, x_n$ are the decision variables to be determined. The inequalities denote the constraints (or restrictions). The coefficients a_{ij} for i =1,2,…,m, and j=1,2,…,n are called the technological coefficients. These technological coefficients form the constraint matrix A.

$$A := \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{pmatrix}$$

The column vector whose ith component is b_j, which is referred to as the right-hand-side vector, represents the minimal requirements to be satisfied. The constraints $x_1, x_2, \dots, x_n \geq 0$ are the non-negativity constraints. A set of variables $x_1, \dots, x_n$ satisfying all the constraints is called a feasible point or a feasible vector. The set of all such point constitutes the feasible region or feasible space.

Using the foregoing terminology, the linear programming problem can be stated as follows: Among all feasible vectors, find one that minimizes (or maximizes) the

objective function (Bazarra 2). Chapter 3 will incorporate this methodology into a general technique to solve the weights of a value focused thinking model with historical data present.

2.6 Summary

This chapter has provided a review of Decision Analysis, Value Focused Thinking, and optimization. These tools will prove critical in the following chapter, where the methodology behind using optimization to select the weights of a VFT hierarchy will be explored.

Chapter 3. Methodology

"A problem well stated is a problem half-solved." (Charles F. Kettering)

3.0 Overview

This chapter illustrates the methodology behind using non-linear programming and genetic algorithms to optimize the weights of a VFT hierarchy. This methodology will be explained both in a numerical and theoretical manner in order to highlight the important facets of using this type of weighting scheme. The chapter begins with a purely mathematical and expandable example, depicting all major aspects of the methodology. This will be followed by a simple example using the defined terminology. Finally, a larger, multi-time-period example will be shown, completing the explanation of this methodology.

The methodology of this chapter will be conducted in a seven-step process:

1) Build the VFT hierarchy, including measures and SDVFs.
2) Obtain the historical data pertaining to each of the measures and the rankings for each time period of interest.
3) Determine appropriate error function, subject to VFT constraints.
4) Formulate the optimization to minimize the error function.
5) Solve for the optimal weights of the hierarchy.
6) Transpose these weights into the hierarchy.
7) Use the hierarchy to predict the rankings of the next time period of interest.

3.1 Mathematical Representation of Methodology

This section will focus on the mathematical representation of the methodology utilized to optimize the weights of a VFT hierarchy. The section begins with breaking down the VFT hierarchy into its elements, followed by defining additional terminology pertinent to this chapter. Finally, an expandable, mathematical formulation of the methodology will be explained.

The following charts and definitions depict the individual elements of a hierarchy (note that hierarchies may be small or large with a varying number of tiers and/or branches):

Fundamental Objective: The overall question one desires to answer. The purpose of the VFT process is to gain insight into this fundamental objective.

Tier of the Hierarchy: A tier of the hierarchy is the common horizontal position of sub-objectives or measures within the hierarchy. There are tradeoffs between any sub-objectives within a tier as long as they fall under a common objective.

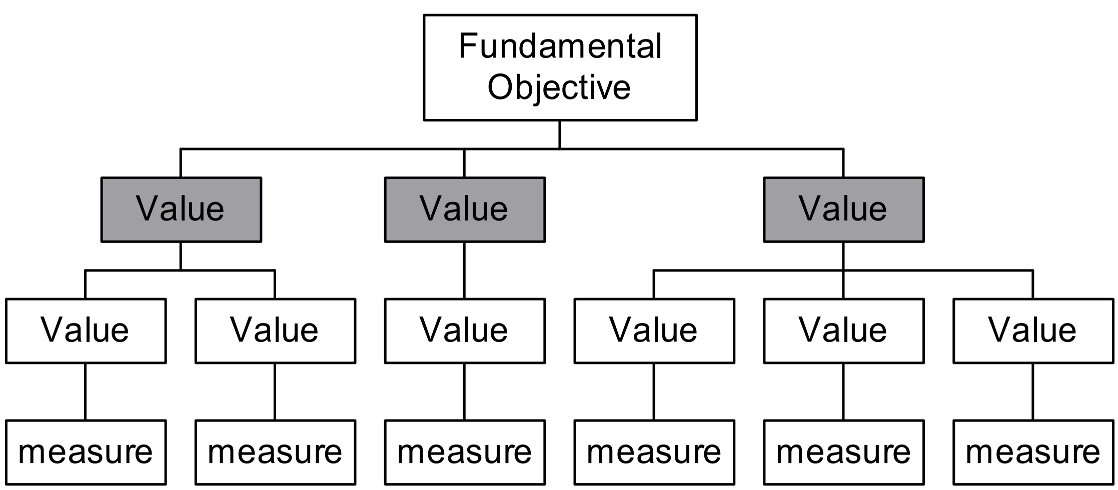


Figure 3.1: First Tier of Hierarchy

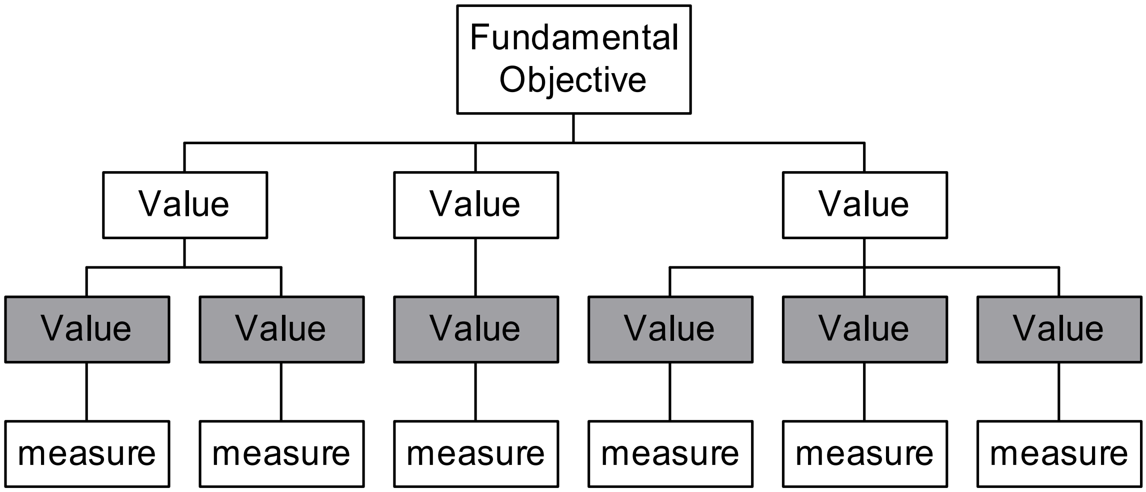


Figure 3.2: Second Tier of Hierarchy

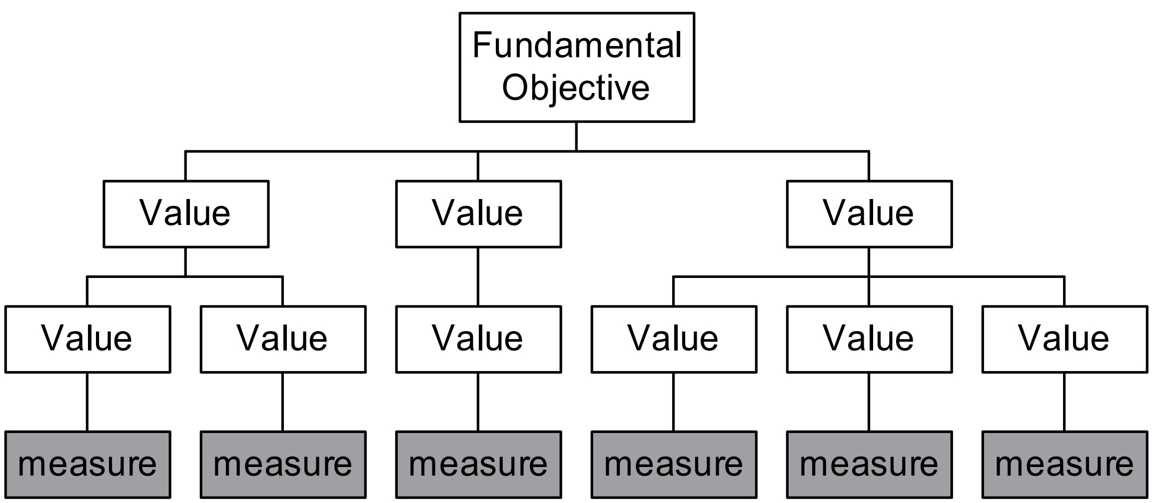


Figure 3.3: Third Tier of Hierarchy (measures in this example)

Branch of the Hierarchy: A branch of a hierarchy is all of the sub-objectives down to measures of the hierarchy, which stem from one of the first tier sub-objectives.

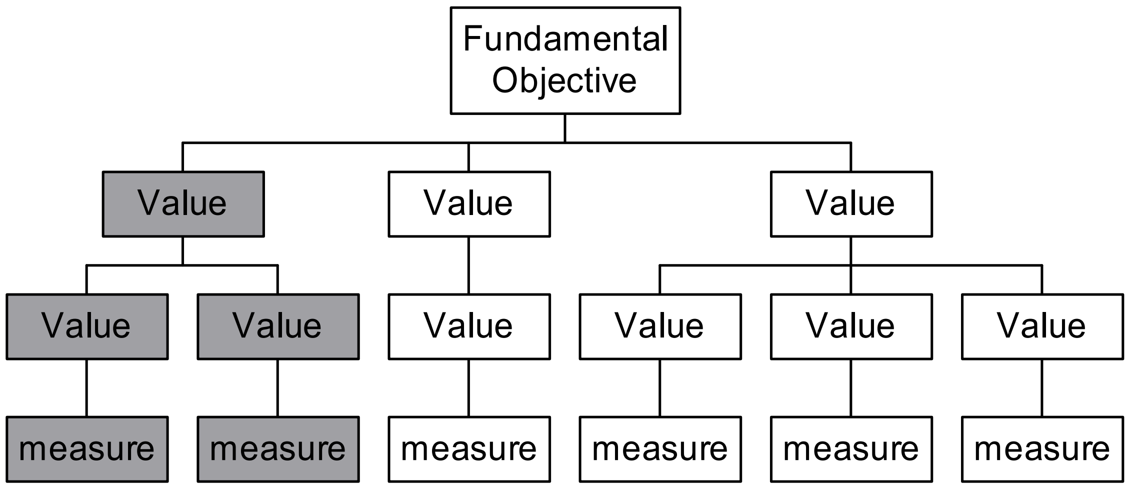


Figure 3.4: First Branch of Hierarchy

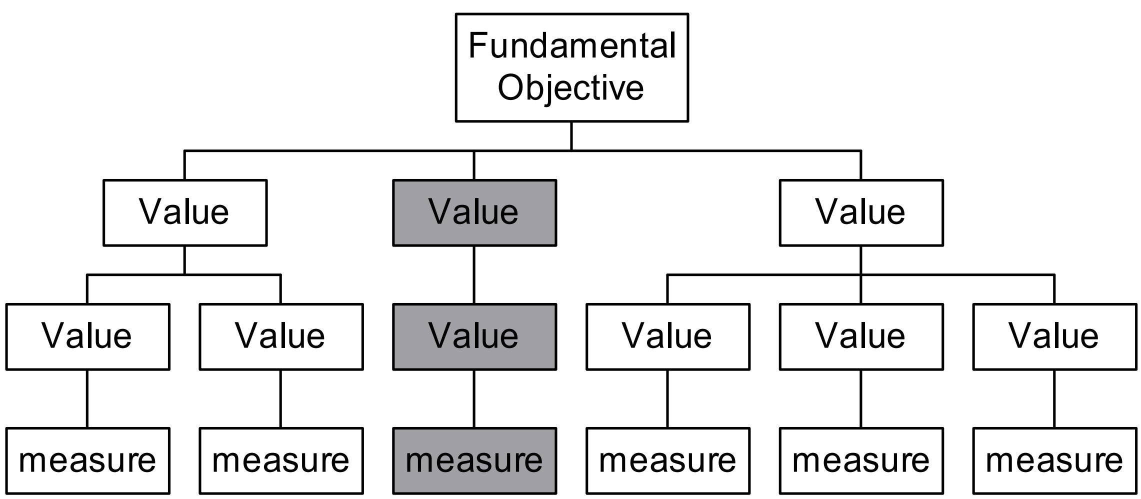


Figure 3.5: Second Branch of Hierarchy

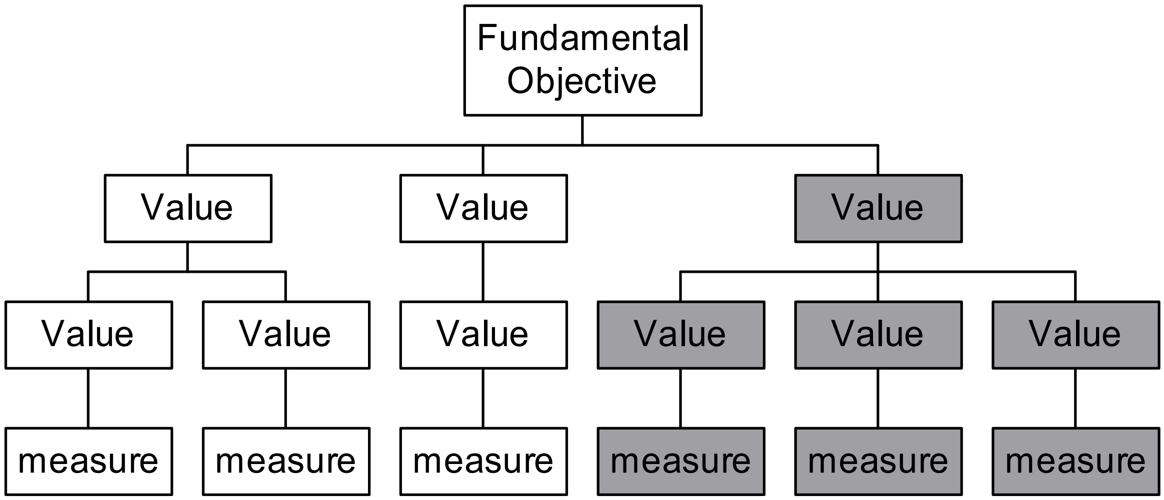


Figure 3.6: Third Branch of Hierarchy

In attempt to give a clear, mathematical formulation of the methodology, consider the following 7-step process of implementing the methodology. First, consider the following, expandable hierarchy:

Step 1: Build Hierarchy

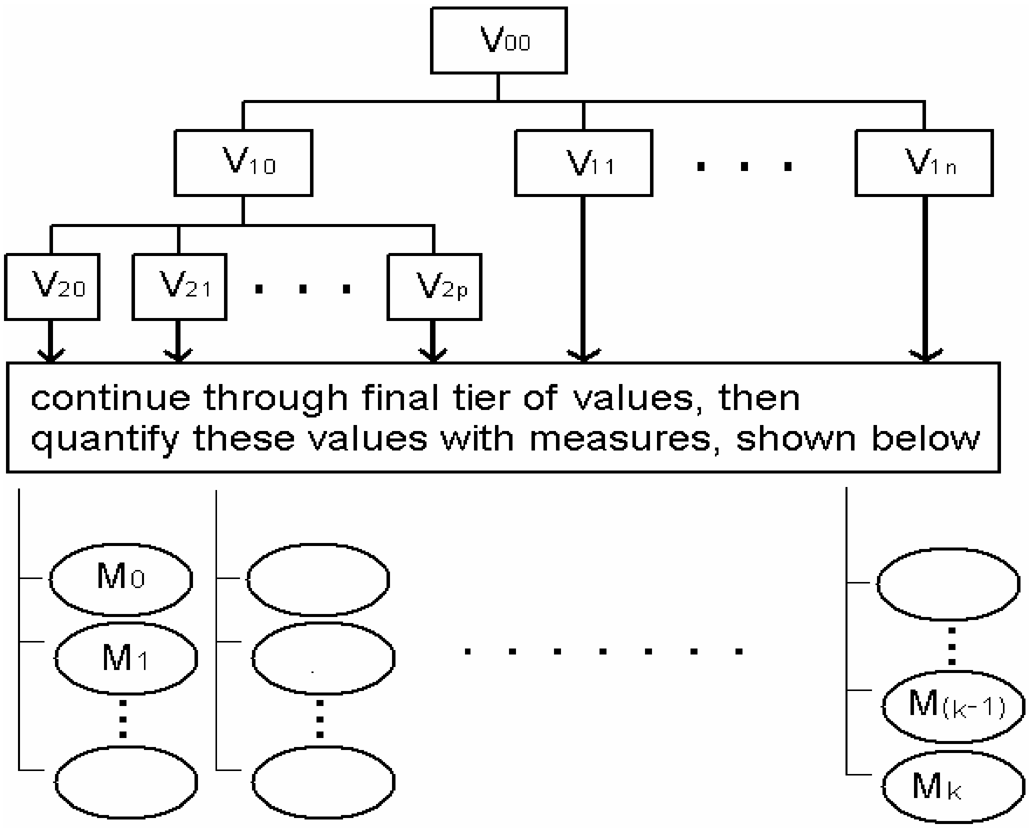


Figure 3.7: Expandable Hierarchy

Definitions for the expandable hierarchy are as follows:

V_{ij} = value in the hierarchy.

> i = tier of the hierarchy. i = 0,1,2…(t-1)
>
> j = value's ordered placement within the i^{th} tier of the hierarchy.

t = final tier of the hierarchy, therefore t-1 represents the last tier of values.

M_j = measure in the hierarchy.

> j = measure's ordered placement within the final tier (t^{th} tier) of the hierarchy.

$j = 1,2\ldots k$

k = total number of measures in the hierarchy.

W_{ij} = local weight assigned to each value (V_{ij}) of the hierarchy.

W_{tj} = local weight assigned to each of the "k" measures (M_j) of the hierarchy.

t = final tier of the hierarchy.

j = measure's ordered placement within the final tier (t'th tier) of the hierarchy.

$j = 1,2\ldots k$

W_{tj}^{g} = global weight of measure j. $j = 1,2\ldots k$

S_i = the overall score of alternative i. $i = 1,2\ldots N$.

$v_j(x_j)$ = y-axis value of measure j, as translated by the SDVF, for one alternate.

D_{ij} = the set of all the descendants of V_{ij}. A set of descendants are all of the values or measures which "descend" from a common parent node (where the parent node is located on tier i-1. The sum of the weights of these descendants must sum to 1: (

$\sum_{v=1}^{k} W_{(i+1),v} \in D_{ij} = 1$)

v = ordered placement within a set of descendants.

k = number of values or measures in the descendant set.

Step 2: Data

In order to complete this process, historical data on each measure, and performance of each alternative is needed. The following table lists the y-axis "values" of the measures after they have been translated into the 0-1 scale by the SDVFs.

Time period 1

	Alt 1	Alt 2	Alt 3	* * * * *	Alt N
M_0	$V_0(x_0)$	$V_0(x_0)$	$V_0(x_0)$	* * * * *	$V_0(x_0)$
M_1	$V_1(x_1)$	$V_1(x_1)$	$V_1(x_1)$	* * * * *	$V_1(x_1)$

M_2	$V_2(x_2)$	$V_2(x_2)$	$V_2(x_2)$	* * * * *	$V_2(x_2)$
:	:	:	:	:	:
M_k	$V_k(x_k)$	$V_k(x_k)$	$V_k(x_k)$	* * * * *	$V_k(x_k)$

Time period 2

	Alt 1	Alt 2	Alt 3	* * * * *	Alt N
M_0	$V_0(x_0)$	$V_0(x_0)$	$V_0(x_0)$	* * * * *	$V_0(x_0)$
M_1	$V_1(x_1)$	$V_1(x_1)$	$V_1(x_1)$	* * * * *	$V_1(x_1)$
M_2	$V_2(x_2)$	$V_2(x_2)$	$V_2(x_2)$	* * * * *	$V_2(x_2)$
:	:	:	:	:	:
M_k	$V_k(x_k)$	$V_k(x_k)$	$V_k(x_k)$	* * * * *	$V_k(x_k)$

: : :

: : :

: : :

Time period f

	Alt 1	Alt 2	Alt 3	* * * * *	Alt N
M_0	$V_0(x_0)$	$V_0(x_0)$	$V_0(x_0)$	* * * * *	$V_0(x_0)$
M_1	$V_1(x_1)$	$V_1(x_1)$	$V_1(x_1)$	* * * * *	$V_1(x_1)$
M_2	$V_2(x_2)$	$V_2(x_2)$	$V_2(x_2)$	* * * * *	$V_2(x_2)$
:	:	:	:	:	:
M_k	$V_k(x_k)$	$V_k(x_k)$	$V_k(x_k)$	* * * * *	$V_k(x_k)$

Figure 3.8: Historical Data

For each time period also exists known rankings, $Rank_{ij}^{k}$, for each alternative:

	Period 1	Period 2	* * * * *	Period f
Alt 1	$Rank_{11}^{k}$	$Rank_{12}^{k}$	* * * * *	$Rank_{1f}^{k}$
Alt 2	$Rank_{21}^{k}$	$Rank_{22}^{k}$	* * * * *	$Rank_{2f}^{k}$
Alt 3	$Rank_{31}^{k}$	$Rank_{32}^{k}$	* * * * *	$Rank_{3f}^{k}$
:	:	:	:	:
Alt N	$Rank_{N1}^{k}$	$Rank_{N2}^{k}$	* * * * *	$Rank_{Nf}^{k}$

Figure 3.9: Historical Rankings

Step 3: Error Function

$$E = \sum_{j=period1}^{periodf} \sum_{i=Alt1}^{AltN} | Rank_{ij}^{k} - Rank_{ij}^{c} |$$

$Rank_{ij}^{k}$ is the known rank of alternative i in time period j, and $Rank_{ij}^{c}$ is the calculated rank of alternative i in time period j. Once again, it is important to note that this is not the only error function that may be used.

Step 4: Formulate Optimization

In order to formulate the optimization, it is first necessary to compute $Rank_{ij}^{c}$. $Rank_{ij}^{c}$ is calculated by rank ordering the overall scores of all N alternatives. In Microsoft Excel, this is done with the command: RANK($Score_1$, $Score_N$). The overall score of an individual alternative, S_i, is calculated by summing the global weights of all of the measures multiplied by their respective $v_j(x_j)$. The global weight of a measure, W_{tj}^{g}, is found by taking the product of the chain of the parent nodes' local weights (up to and including the objective function), and multiplying that value by the local weight of that measure, W_{tj}:

$$W_{tj}^{g} = W_{tj} * \prod_{ij = W_{tj}\text{'s parent node}}^{\text{Obj Function}} W_{ij}$$

Therefore, alternative i's overall score is calculated:

$$S_i = \sum_{j=0}^{k} W_{tj}^{g} * v_j(x_j)$$

In turn the calculated ranking of alternative i in period j, $Rank_{ij}^{c}$ is the ranking of S_i among all N alternatives, in period j. With this notation defined, a mathematical representation of the optimization is as follows:

$$\text{Minimize } E = \sum_{j=period1}^{period\ f} \sum_{i=Alt1}^{AltN} | Rank_{ij}^{k} - Rank_{ij}^{c} |$$

Subject to: $\sum W_{ij} = 1 \ \forall \ W_{(i+1),v} \in D_{ij}$ (the sum of all local weights = 1, i = 1…t-1)

$$0 \le W_{ij} \le 1 \qquad \text{(all weights must be between zero and one)}$$

Step 5, 6, & 7:

Using Excel's Premium Solver, solve for the optimal weights of the hierarchy. Integrate these optimized weights into the original hierarchy. With a complete hierarchy, one may now score a current list of alternatives, and predict the ordinal outcome of these alternatives.

3.2 Example 1

The following examples in this chapter are not real-world scenarios, with fictitious hierarchies and data. Consider the following example, conducted using the 7-step process.

Step 1: Build Hierarchy

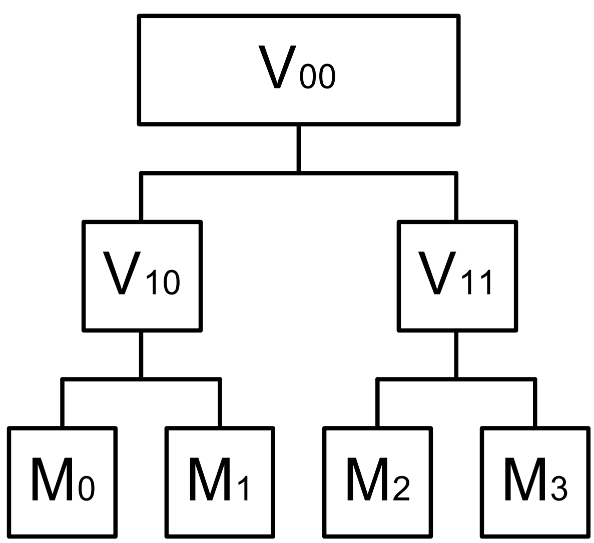


Figure 3.10: Hierarchy Ex. 1

Step 2: Obtain Historical Data

Consider the following data, created solely for the purpose of illustration:

	Alt 1	Alt 2	Alt 3	Alt 4
V0(x0)	0.6	0.9	0.1	0.4
V1(x1)	0.8	0.5	0.6	0.95
V2(x2)	0.9	0.8	0.7	0.6
V3(x3)	0.9	0.9	0.3	0.2
Rank(K)	2	1	4	3

Figure 3.11: Data Ex. 1

$$\mathrm{S_i} = \sum_{j=0}^{3} \mathrm{W_{tj}}^{\mathrm{g}} * V_j(X_j) \quad \therefore$$

$$S_1 = W_{10} * W_{20} * .6 + \mathrm{W}_{10} * W_{21} * .8 + W_{12} * W_{23} * .9 + W_{12} * W_{24} * .9$$

$$S_2 = W_{10} * W_{20} * .9 + \mathrm{W}_{10} * W_{21} * .5 + W_{12} * W_{23} * .8 + W_{12} * W_{24} * .9$$

$$S_3 = W_{10} * W_{20} * .1 + \mathrm{W}_{10} * W_{21} * .6 + W_{12} * W_{23} * .7 + W_{12} * W_{24} * .3$$

$$S_4 = W_{10} * W_{20} * .4 + \mathrm{W}_{10} * W_{21} * .95 + W_{12} * W_{23} * .6 + W_{12} * W_{24} * .2$$

Step 3: Error Function

The error function would be varied to see how it effects the outcome, but an example where no emphasis is placed on priority of matched rankings is as follows:

Min E =

$$(|\, Rank_{11}{}^{k} - Rank_{11}{}^{c} \,| + |\, Rank_{21}{}^{k} - Rank_{21}{}^{c} \,| + |\, Rank_{31}{}^{k} - Rank_{31}{}^{c} \,| + |\, Rank_{41}{}^{k} - Rank_{41}{}^{c} \,|)$$

Step 4: Formulate Optimization

Using the known rankings, the entire optimization would be:

Min Z = $(|\, 2 - Rank_{11}{}^{c} \,| + |\, 1 - Rank_{21}{}^{c} \,| + |\, 4 - Rank_{31}{}^{c} \,| + |\, 3 - Rank_{41}{}^{c} \,|)$

subject to:

$$W_{10} + W_{11} = 1$$

$$W_{20} + W_{21} = 1$$

$$W_{23} + W_{24} = 1$$

$$W_{10}, W_{20}, W_{11}, W_{21}, W_{23}, W_{24} \leq 1$$

$$W_{10}, W_{20}, W_{11}, W_{21}, W_{23}, W_{24} \geq 0$$

Step 5: Solve for optimal weights

Excel's Evolutionary Solver was the optimization package chosen for this analysis. Within Excel, the weights of the hierarchy are changed for a specified number of iterations or candidate solutions, with the goal of minimizing the objective/ error function. With each different run the weights vary slightly (because of the starting conditions and inherent randomness of the genetic algorithm), however the general weighting scheme remains the same. For the above example, one of the optimal solutions is shown below:

	Alt 1	Alt 2	Alt 3	Alt 4
V0(x0)	0.6	0.9	0.1	0.4
V1(x1)	0.8	0.5	0.6	0.95
V2(x2)	0.9	0.8	0.7	0.6
V3(x3)	0.9	0.9	0.3	0.2
Rank(K)	2	1	4	3
Score	0.781327	0.79849	0.403613	0.517833
Rank(C)	**2**	**1**	**4**	**3**
Error	**0**			
	Value Weight		**Measure Weight**	
0		**0.512608**	**0.651107**	
1		**0.486741**	**0.349608**	
2			**0.599959**	
3			**0.399202**	

Figure 3.12: Output Ex. 1

Step 6: Transpose these weights into the hierarchy:

This output translates to the optimal weighting of the hierarchy which minimizes the error function:

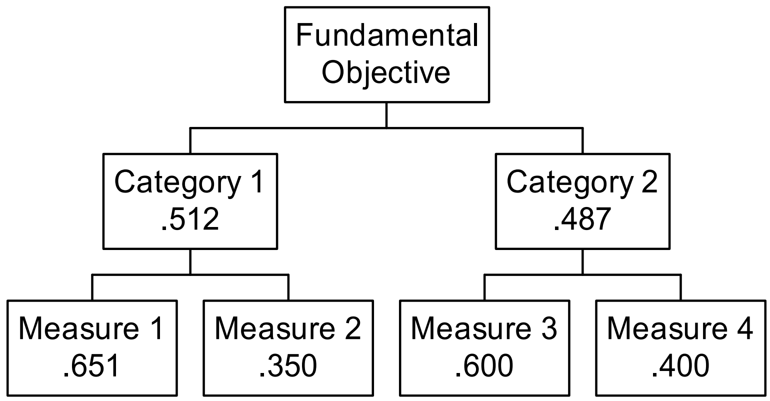


Figure 3.13: Weighted Hierarchy Ex. 1

Step 7: Use Hierarchy To Rank Current Period

This hierarchy, with completed weights may be used to score a current list of alternatives, and predict the ordinal outcome of these alternatives.

3.3: Example 2

The previous example was trivial. Now consider the following example, using fictitious data once again, but now expanding the area of interest over four time periods, which will be denoted by quarters 1-4.

Step 1: Hierarchy

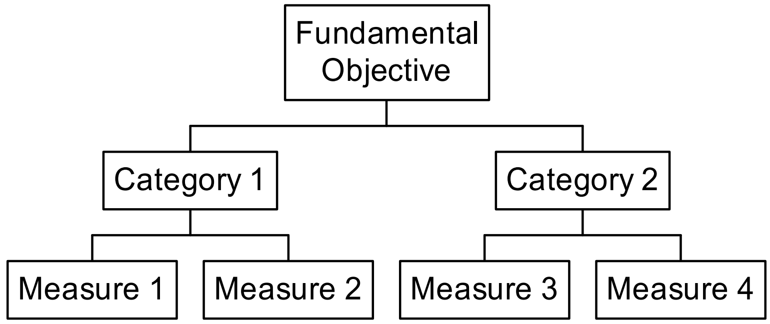


Figure 3.14: Hierarchy Ex. 2

Step 2: Obtain Historical Data

Quarter 1				
	Alt A	Alt B	Alt C	Alt D
V0(x0)	0.6	0.9	0.1	0.4
V1(x1)	0.8	0.5	0.6	0.95
V2(x2)	0.9	0.8	0.7	0.6
V3(x3)	0.9	0.9	0.3	0.2
Rank(K)	2	1	4	3
Quarter 2				
	Alt A	Alt B	Alt C	Alt D
V0(x0)	0.4	0.4	0.7	0.2
V1(x1)	0.7	0.5	0.3	0.8
V2(x2)	0.5	0.5	0.5	0.5
V3(x3)	0.4	0.5	0.7	0.6
Rank	4	3	1	2
Quarter 3				
	Alt A	Alt B	Alt C	Alt D
V0(x0)	0.6	0.5	0.9	1
V1(x1)	0.5	0.4	0.8	0.3
V2(x2)	0.8	0.7	0.6	0.7
V3(x3)	0.6	0.6	0.8	0.8
Rank	3	4	2	1
Quarter 4				
	Alt A	Alt B	Alt C	Alt D
V0(x0)	0.9	0.6	0.8	0.8
V1(x1)	0.7	0.6	0.5	0.4
V2(x2)	0.2	0.5	0.6	0.1
V3(x3)	1	0.1	0.5	0.7
Rank	1	4	3	2

Figure 3.15: Data Ex. 2

As you can see in the formulation below, scoring must be done for each quarter, and the error function must be expanded to include all quarters, but the same fundamentals hold:

$$\mathrm{S_i} = \sum_{j=0}^{3} \mathrm{W_{tj}}^{\mathrm{g}} * V_j(X_j) \quad \therefore$$

$$S_{A1} = W_{10} * W_{20} * .6 + \mathrm{W}_{10} * W_{21} * .8 + W_{12} * W_{23} * .9 + W_{12} * W_{24} * .9$$

$$S_{B1} = W_{10} * W_{20} * .9 + \mathrm{W}_{10} * W_{21} * .5 + W_{12} * W_{23} * .8 + W_{12} * W_{24} * .9$$

:   :

:   :

$$S_{C4} = W_{10} * W_{20} * .8 + W_{10} * W_{21} * .5 + W_{12} * W_{23} * .6 + W_{12} * W_{24} * .5$$

$$S_{D4} = W_{10} * W_{20} * .8 + W_{10} * W_{21} * .4 + W_{12} * W_{23} * .1 + W_{12} * W_{24} * .7$$

Step 3: Error Function

$$\text{Min Z} = \begin{array}{l} (|\, 2 - Rank_{A1}{}^{c} \,| + |\, 1 - Rank_{B1}{}^{c} \,| + |\, 4 - Rank_{C1}{}^{c} \,| + |\, 3 - Rank_{D1}{}^{c} \,|) + \\ (|\, 4 - Rank_{A2}{}^{c} \,| + |\, 3 - Rank_{B2}{}^{c} \,| + |\, 1 - Rank_{C2}{}^{c} \,| + |\, 2 - Rank_{D2}{}^{c} \,|) + \\ (|\, 3 - Rank_{A3}{}^{c} \,| + |\, 4 - Rank_{B3}{}^{c} \,| + |\, 2 - Rank_{C3}{}^{c} \,| + |\, 1 - Rank_{D3}{}^{c} \,|) + \\ (|\, 1 - Rank_{A4}{}^{c} \,| + |\, 4 - Rank_{B4}{}^{c} \,| + |\, 3 - Rank_{C4}{}^{c} \,| + |\, 2 - Rank_{D4}{}^{c} \,|) \end{array}$$

Step 4: Set up optimization

$$\text{Min Z} = \begin{array}{l} (|\, 2 - Rank_{A1}{}^{c} \,| + |\, 1 - Rank_{B1}{}^{c} \,| + |\, 4 - Rank_{C1}{}^{c} \,| + |\, 3 - Rank_{D1}{}^{c} \,|) + \\ (|\, 4 - Rank_{A2}{}^{c} \,| + |\, 3 - Rank_{B2}{}^{c} \,| + |\, 1 - Rank_{C2}{}^{c} \,| + |\, 2 - Rank_{D2}{}^{c} \,|) + \\ (|\, 3 - Rank_{A3}{}^{c} \,| + |\, 4 - Rank_{B3}{}^{c} \,| + |\, 2 - Rank_{C3}{}^{c} \,| + |\, 1 - Rank_{D3}{}^{c} \,|) + \\ (|\, 1 - Rank_{A4}{}^{c} \,| + |\, 4 - Rank_{B4}{}^{c} \,| + |\, 3 - Rank_{C4}{}^{c} \,| + |\, 2 - Rank_{D4}{}^{c} \,|) \end{array}$$

subject to:

$$W_{10} + W_{11} = 1$$

$$W_{20} + W_{21} = 1$$

$$W_{23} + W_{24} = 1$$

$$W_{10}, W_{20}, W_{11}, W_{21}, W_{23}, W_{24} \le 1$$

$$W_{10}, W_{20}, W_{11}, W_{21}, W_{23}, W_{24} \ge 0$$

Step 5: Solve for optimal weights

After running the Premium Solver on this problem, one of the optimal solutions was as follows:

Quarter 1				
	Alt A	Alt B	Alt C	Alt D
V0(x0)	0.6	0.9	0.1	0.4
V1(x1)	0.8	0.5	0.6	0.95
V2(x2)	0.9	0.8	0.7	0.6
V3(x3)	0.9	0.9	0.3	0.2
Rank(K)	2	1	4	3
Score	**0.799438**	**0.849656**	**0.328115**	**0.386037**
Rank(S)	**2**	**1**	**4**	**3**
Error	**0**			
Quarter 2				
	Alt A	Alt B	Alt C	Alt D
V0(x0)	0.4	0.4	0.7	0.2
V1(x1)	0.7	0.5	0.3	0.8
V2(x2)	0.5	0.5	0.5	0.5
V3(x3)	0.4	0.5	0.7	0.6
Rank	4	3	1	2
Score	**0.439911**	**0.46884**	**0.633814**	**0.477917**
Rank(S)	**4**	**3**	**1**	**2**
Error	**0**			
Quarter 3				
	Alt A	Alt B	Alt C	Alt D
V0(x0)	0.6	0.5	0.9	1
V1(x1)	0.5	0.4	0.8	0.3
V2(x2)	0.8	0.7	0.6	0.7
V3(x3)	0.6	0.6	0.8	0.8
Rank	3	4	2	1
Score	**0.62319**	**0.568577**	**0.796479**	**0.802247**
Rank(S)	**3**	**4**	**2**	**1**
Error	**0**			
Quarter 4				
	Alt A	Alt B	Alt C	Alt D
V0(x0)	0.9	0.6	0.8	0.8
V1(x1)	0.7	0.6	0.5	0.4
V2(x2)	0.2	0.5	0.6	0.1
V3(x3)	1	0.1	0.5	0.7
Rank	1	4	3	2
Score	**0.813982**	**0.356695**	**0.606147**	**0.607456**
Rank(S)	**1**	**4**	**3**	**2**
Error	**0**			

	Category Weight		Measure Weight	
1	0.383787		0.788928	
2	0.61437		0.212117	
3			0.263592	
4			0.735885	

Figure 3.16: Output Ex. 2

Step 6: Transpose Weights Into Hierarchy

This output translates to the optimal weighting of the hierarchy which minimizes the error function:

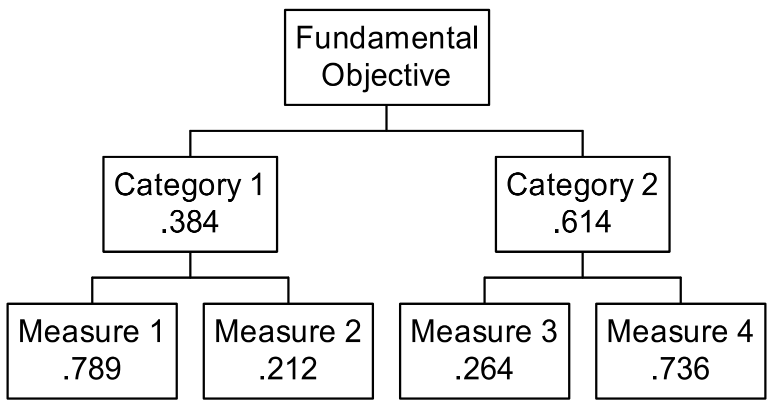


Figure 3.17: Complete Hierarchy Ex. 2

This weighting minimized the difference between known and calculated rankings over each of these four time periods. In this particular example, the weighting was effective to the extent that scoring any of the four quarters with the above weighting scheme, resulted in an error of zero.

Step 7: Use Hierarchy To Rank Current Period

This hierarchy, with completed weights may be used to score a current list of alternatives, and predict the ordinal outcome of these alternatives.

3.4 Summary

This chapter has provided detailed methodology behind using optimization to select the weights of a VFT hierarchy. The mathematical, expandable example should prove useful as a shell for any problem using this 7-step methodology. Chapter 4 will implement this methodology on solving the problem of deciding the relative importance of military construction (MILCON) projects.

Chapter 4. Results and Analysis

4.0 Overview

This chapter will provide an example of using optimization to determine the weighting scheme of a value focused thinking hierarchy. This example is a broad overview of the process, and although it highlights the civil engineering arena, the goal of this chapter is to clearly depict how this methodology could apply to most any area of study.

4.1 MILCON Project Selection as an Example

"The mission of HQ USAF/ILE, the Office of The Civil Engineer, is to provide the bases, infrastructure and facilities necessary to support the global engagement of air and space forces across the spectrum of conflict" (Installation). AIR FORCE PAMPHLET 32-1004, VOLUME 1, breaks down Air Force Civil Engineering in the following manner:

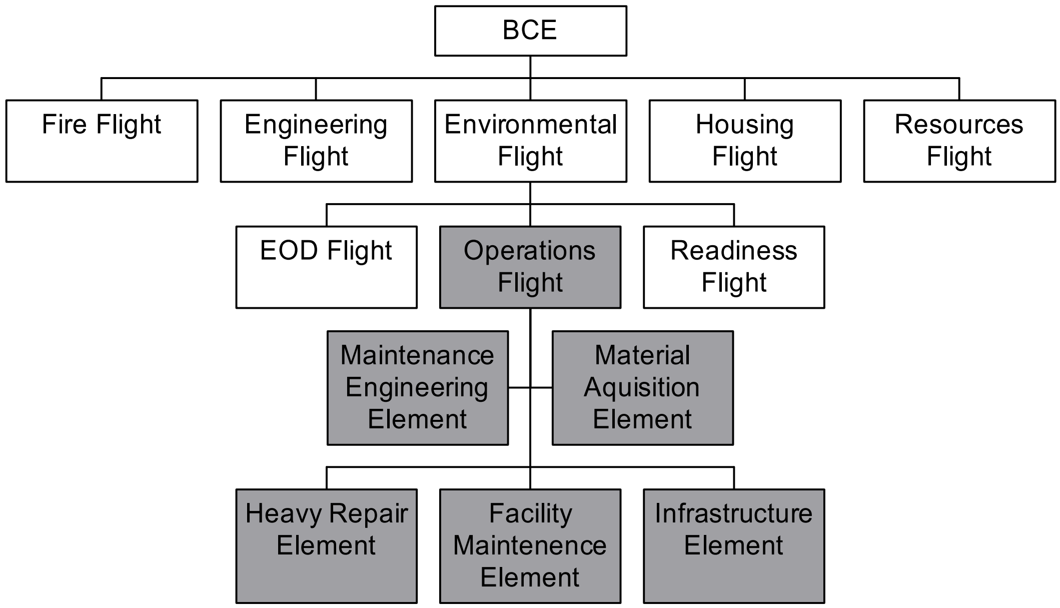


Figure 4.1: Base Civil Engineering Hierarchy

Within this hierarchy, the Engineering Flight is the facet in charge of any major construction on an Air Force installation. Each base is allocated a certain budget to take care of routine, small construction and maintenance. When a major project must be completed, however, approval for funding must go through the "MILCON" (Military Construction) approval process. A military construction project, as defined by Air Force Instruction 32-1021 is:

> Military construction as defined in the law includes any construction, development, conversion, or extension of any kind carried out with respect to a military installation. It includes all construction work necessary to produce a complete and usable facility or a complete and usable improvement to an existing facility. Authority to carry out a military construction project includes authority for surveys and site preparation; acquisition, conversion, rehabilitation, or installation of facilities; acquisition and installation of equipment and appurtenances integral to the project; acquisition and installation of supporting facilities (including utilities) and appurtenances incident to the project; and planning, supervision, administration, and overhead incident to the project. (16)

The current monetary threshold for a MILCON project is $750,000 (Dempsey). The time it takes from initial proposal to approval and the start of construction is typically a minimum of two years (Dempsey). The MILCON process flow-chart as given by The United States Air Force Program Manager's Guide for Design and Construction, is shown in figure 4.2:

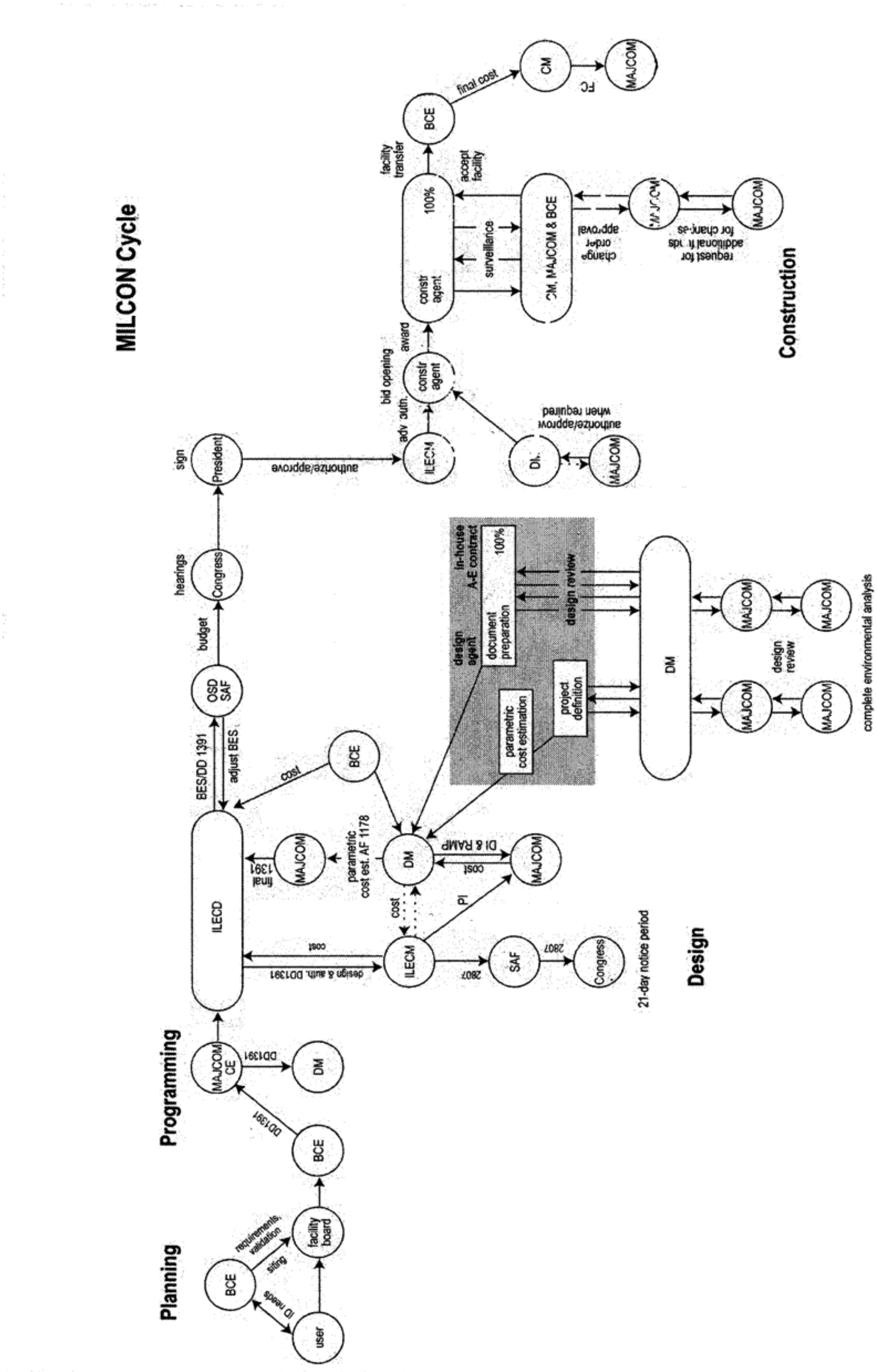


Figure 4.2: MILCON Cycle

The first steps of the MILCON process are summarized by the following descriptions taken from AFI 32-1021:

> **Project Identification and Prioritization:** Installations must identify facility needs, and determine which cannot be met with existing facilities. Installation commanders assisted by the base Facilities Board will review, validate and prioritize the installation MILCON facility requirements. In accordance with schedules established by the MAJCOM, the Civil Engineering Squadron Commander will prepare and submit the DD Forms 1391, 1391C, **FY__ Military Construction Project Data**, AF Form 1178, **Project Cost Estimate Summary**, and enter the project into the Program, Design and Construction data system. A Parametric Cost Estimate and economic analyses (AFI 65-501, *Economic Analysis and Program Evaluation for Resource Management*) must also be submitted to the host or tenant MAJCOM as appropriate. Based on the Installations' submittals HQ USAF/CECD will complete the DD Form 1390, **FY 19 __ Military Construction Program** (S&U, HQ USAF/CECD, 1260 Air Force Pentagon, Washington, DC 20330-1260, DoD Financial Management Regulation, Volume 2B, Chapter 6.) For ANG projects, the Civil Engineering Squadron Commander submits projects to NGB/CEDD. DD Forms 1390S1 and 1390S2, **FY__ Guard and Reserve Military Construction**, will be submitted to Headquarters Air Force Reserves for their projects.
>
> **MAJCOM MILCON Budget:** The MAJCOM civil engineer and functional staff will review and verify data submitted by the command's installations. The MAJCOM commander will evaluate and prioritize the projects and develop and submit a command program (via hard copy and Programming, Design, and Construction computer system) to HQ USAF/CEC that matches the MILCON program element totals established by HQ USAF Resource Allocation Teams. MAJCOMs may submit projects over and above these MILCON totals to HQ USAF/CEC who will review and validate them. Additional funds, however, must be requested by MAJCOM/XPs through the HQ USAF Resource Allocation Teams.
>
> **Air Force MILCON Budget:** HQ USAF/CEC, in conjunction with other HQ USAF functional offices will review each project in detail and validate need, engineering feasibility, economic benefits, compliance with Air Force objectives, and project cost. HQ USAF/CEC will authorize initiation of design on validated projects. Notification per 10 U.S.C. 2807 may be required prior to award of an architect-engineer design contract. (18)

When the Air Staff reviews the MILCON project requests, the projects go through a prioritization process. The goal of this process is to rack and stack all of the projects in order of their importance/priority. With this rank-ordered list, funds may be allocated in a manner the best suits the Air Force's needs. This prioritization process for MILCON projects has historically been done so in the following manner (Rafferty 2002):

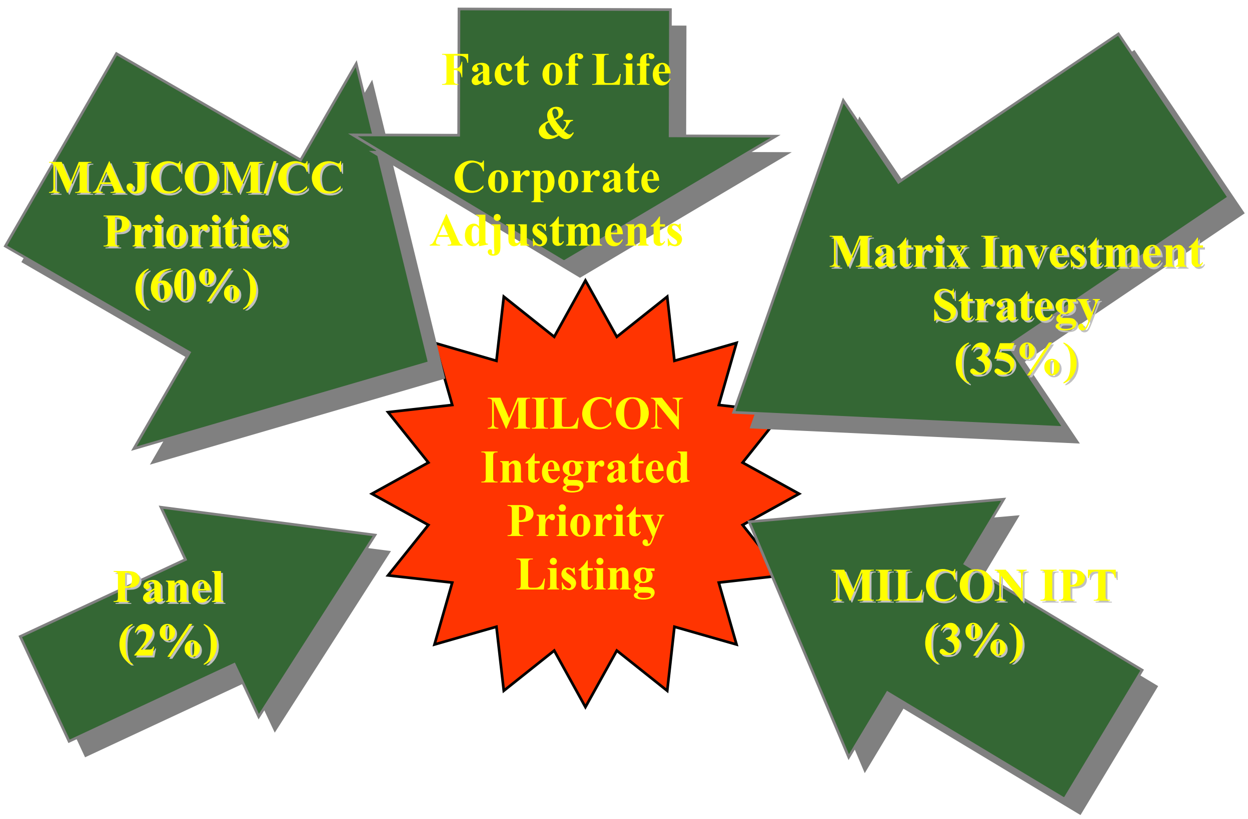


Figure 4.3: MILCON Integrated Priority Listing

The problem with this priority listing is that the corporate adjustments have dominated the prioritization process. The initial purpose of the corporate adjustments was to override the prioritization process for a MILCON project that was absolutely critical.

Over time, unfortunately, the number of projects that are "corporately adjusted" has risen to over 90%. With these statistics, if one wishes to have any chance of their MILCON project being approved, the solicitation for the project must be done so in such a manner deserving of corporate adjustment. Otherwise, it will be one of the only projects that are actually prioritized through the model, and the odds of receiving funding is dismal. Major Andre Dempsey is proposing a new way to prioritize MILCON projects. Using Value Focused Thinking, all projects will be evaluated by a hierarchy with the fundamental objective of determining "what is valued in a MILCON project." The resulting scores of the alternatives will determine the priority of the MILCON projects. Using Dempsey's hierarchy, and the abundance of historical data available for the measures of his hierarchy, the following sections will illustrate this real-world example of using the 7-step process to solve for the optimal weights of a VFT hierarchy.

4.2 Example 1: Solving For Historical Weights

In this example, the "known" rankings are the rankings previously determined during the prioritization process (the rankings the board made). Therefore, this analysis will show which areas the selection board valued highly, and which areas they did not. This type of implementation is useful in illustrating parts of the decision that were left out, but in reality should be influential. These weights will be compared to those determined by Dempsey, that he feels best allocate available weight among the values. This will highlight the major value gaps with the old prioritization process.

4.2.1 Step 1: Develop the Hierarchy

Fundamental Objective: What is Valued in a MILCON Project?

Maj. Andre Dempsey developed the following hierarchy, broken down into its three branches:

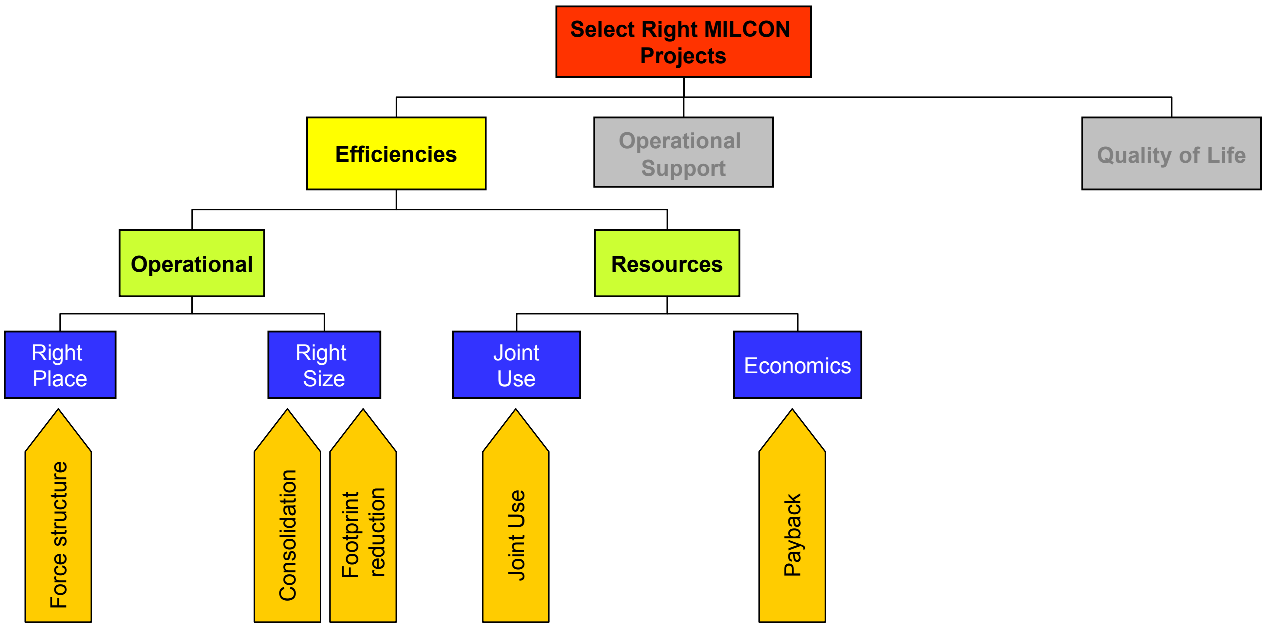


Figure 4.4: MILCON Hierarchy (Branch 1)

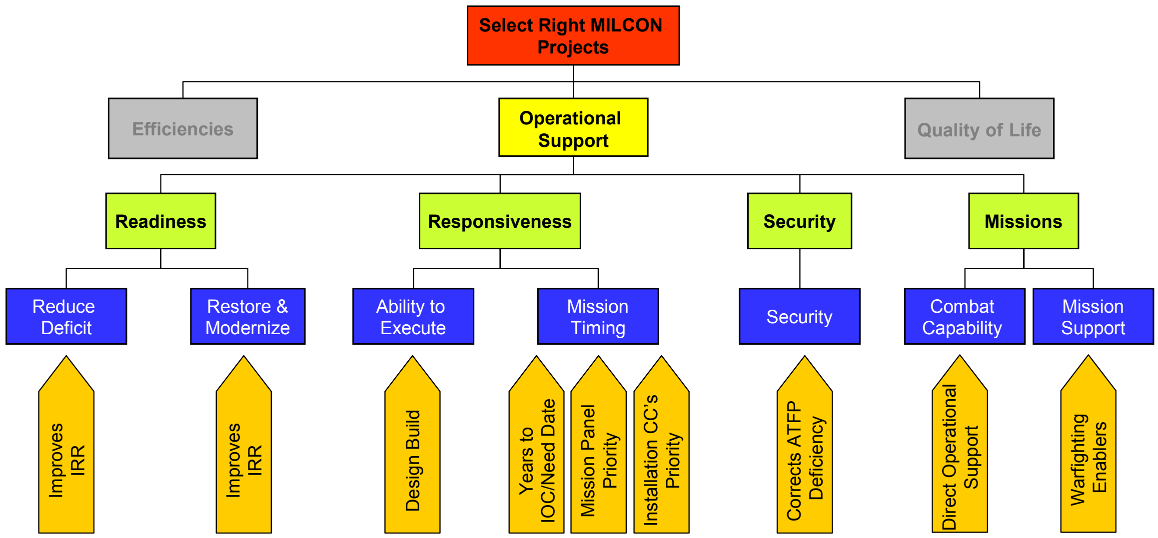


Figure 4.5: MILCON Hierarchy (Branch 2)

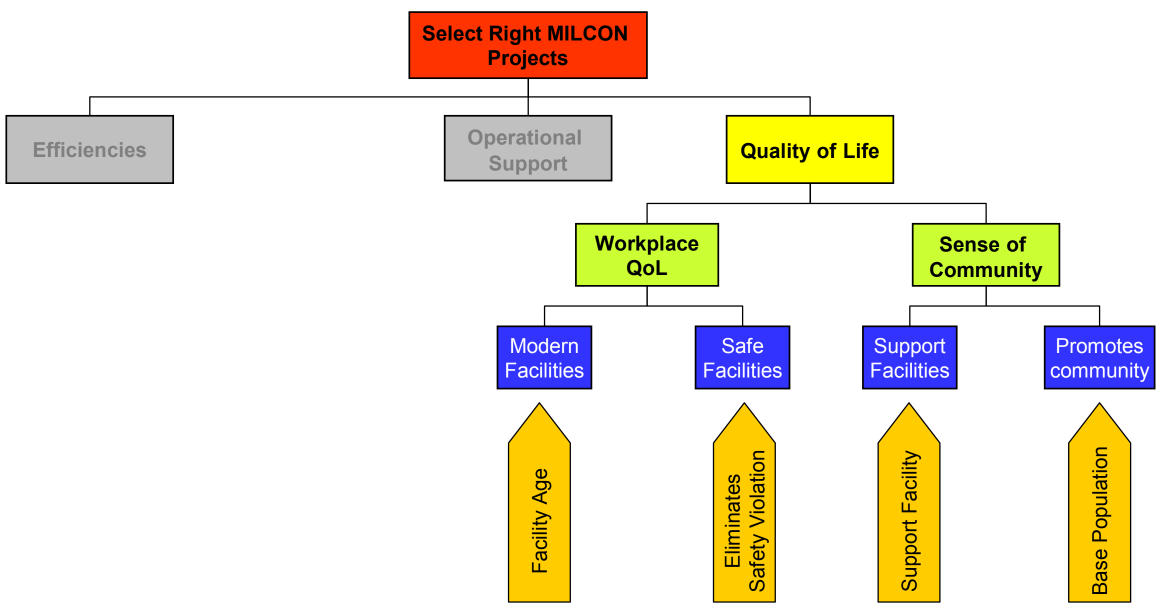


Figure 4.6: MILCON Hierarchy (Branch 3)

4.2.2 Step 2: Obtain Historical Data for Measures

Since the historical data for this example covers 200 alternates, the large list of data may be found in Appendix A. This data includes the y-value scores after translation by the SDVFs, and the alternates are in rank ordered score from one through two hundred.

4.2.3 Step 3: Develop Error Function

With only one time period, and no priority on matching up any rankings of alternates over others, the error function is:

Min E = $(|\,Rank_{11}{}^{k} - Rank_{11}{}^{c}\,| + |\,Rank_{21}{}^{k} - Rank_{21}{}^{c}\,| + .\ .\ . + |\,Rank_{200}{}^{k} - Rank_{200}{}^{c}\,|)$

4.2.4 Step 4: Create Optimization

Minimize $E = \sum_{j=period1}^{period1} \sum_{i=Alt1}^{Alt200} |\,Rank_{ij}{}^{k} - Rank_{ij}{}^{c}\,|$

Subject to: $\sum W_{ij} = 1 \ \forall \ W_{(i+1),v} \in D_{ij}$ (the sum of all local weights = 1, i = 1,2,3,4,5)

$0 \le W_{i\,j} \le 1$ (all weights must be between zero and one)

Definitions for any of the above calculations may be reviewed in chapter 3.

4.2.5 Step 5: Solve for Optimal Weights

This step of the VFT process was done in Excel's Premium Solver. Solver was unable to determine a weighting scheme that resulted in an absolute error = 0 for all two hundred alternatives. This task may or may not be possible, but from the areas of the

solution space explored by Solver, the local minimums found for 50 independent runs may be viewed in Appendix B.

4.2.6 Step 6: Integrate Weights Into Hierarchy

Table 4.5 provides the weighting for the complete hierarchy, including the local weights of the values, and global weights of the measures. These weights were chosen for their low absolute error in difference between "known" and "calculated" rankings of alternatives:

0.0279					0.9356									0.0319			
0.5029			0.4979		0.2558		0.2528				0.2319	0.2545		0.5071		0.4921	
0.4049	0.5959		0.2767	0.7241	0.9789	0.0205	0.0567	0.9399			1.0000	0.0884	0.9114	0.0886	0.0693	0.9469	0.0532
1.0000	0.4494	0.8376	1.0000	1.0000	1.0000	1.0000	1.0000	0.0226	0.8908	0.0884	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.0057	0.0038	0.0070	0.0038	0.0101	0.2342	0.0049	0.0134	0.0050	0.1981	0.0197	0.2170	0.0210	0.2170	0.0014	0.0011	0.0149	0.0008

Figure 4.7: Weights of Hierarchy (Example 1)

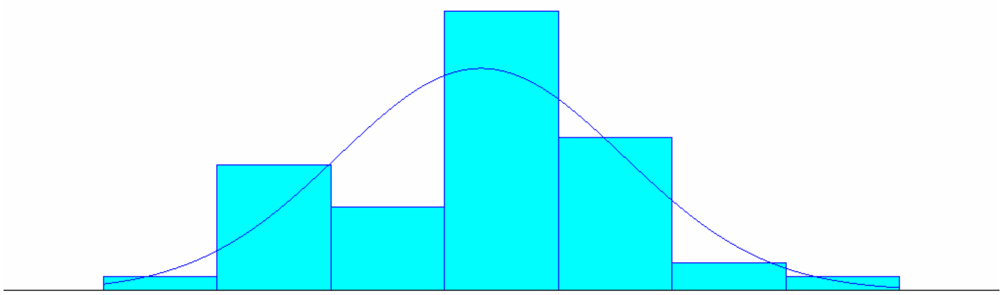
4.2.7 Step 7: Use Hierarchy to Rank Alternatives

The complete hierarchy may now be used to rank a current list of alternatives. This list would be the best guess at how the MICON projects would be ranked by the panel, if they continue their prioritization process under the same trends.

4.2.8 Summary of Findings From Example 1

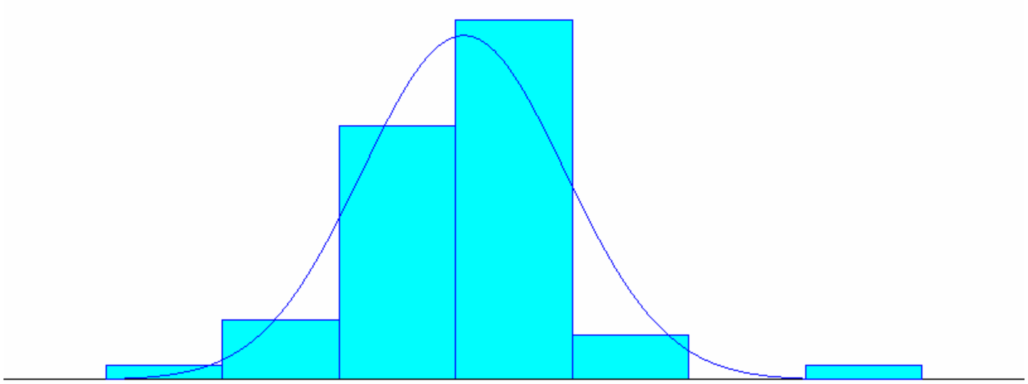
Apparent from the derived weights for the chosen optimization run, historically the MILCON prioritization process has been driven by Deficit IRR, Mission Panel Points, and Correcting an AFTP Deficiency. Corporate adjustment was mentioned earlier as being a necessity in the prioritization process, if a project had hope of approval. Data

was only available on the first 200 alternatives, all which were corporately adjusted, therefore it did not return a high weight in the optimization process. Once again, weights differ between runs due to the convergence on multiple local minimums. The distribution of the weights over fifty runs proved to be normal. This is desirable, for it shows that the weights from the different runs follow a pattern, with most runs falling very close to the mean. Histograms showing the distributions around the first tier of values are:



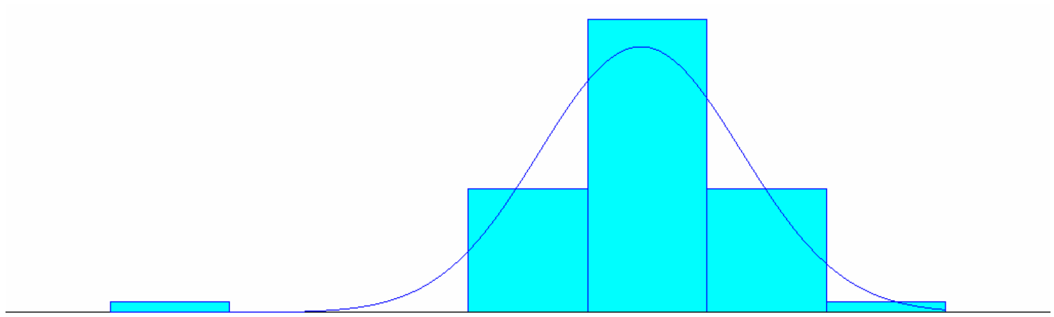
Distribution: Normal
Expression: NORM(0.175, 0.0662)
Square Error: 0.032339

Figure 4.8: Distribution of Weights (Efficiencies Value)



Distribution: Normal
Expression: NORM(0.59, 0.0904)
Square Error: 0.014304

Figure 4.9: Distribution of Weights (Operational Support Value)



Distribution: Normal
Expression: NORM(0.235, 0.0446)
Square Error: 0.009226

Figure 4.10: Distribution of Weights (Quality of Life Value)

4.3 Example 2: Solving For Known Weights

In this example, using the hierarchy with weights determined by Dempsey, the alternatives will be re-scored, and the 7-step process will be used to determine how close the optimization's weights come to those "known" weights that Dempsey used to ordinally rank the alternates.

4.3.1 Step 1: Develop the Hierarchy

Fundamental Objective: What is Valued in a MILCON Project?

The following hierarchy was developed by Maj. Andre Dempsey, and is the same hierarchy as in Example 1:

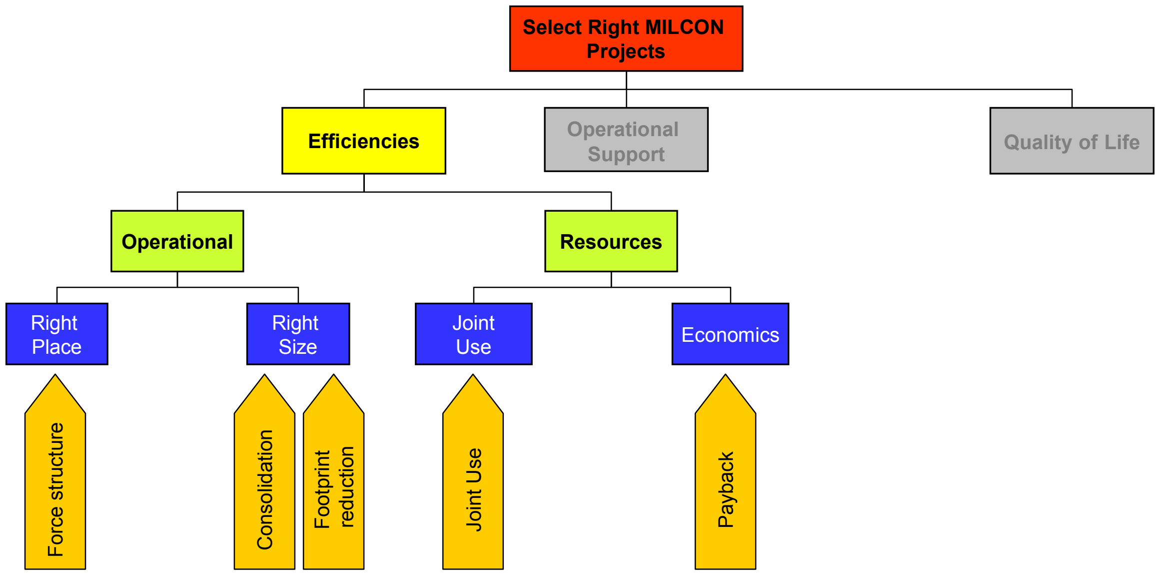


Figure 4.11: MILCON Hierarchy (Branch 1)

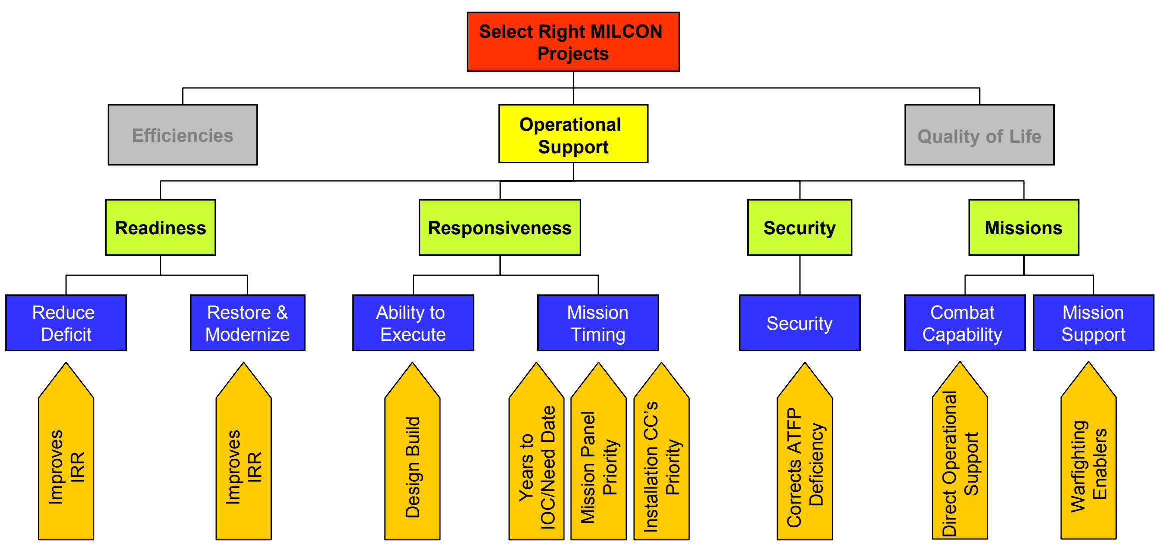


Figure 4.12: MILCON Hierarchy (Branch 2)

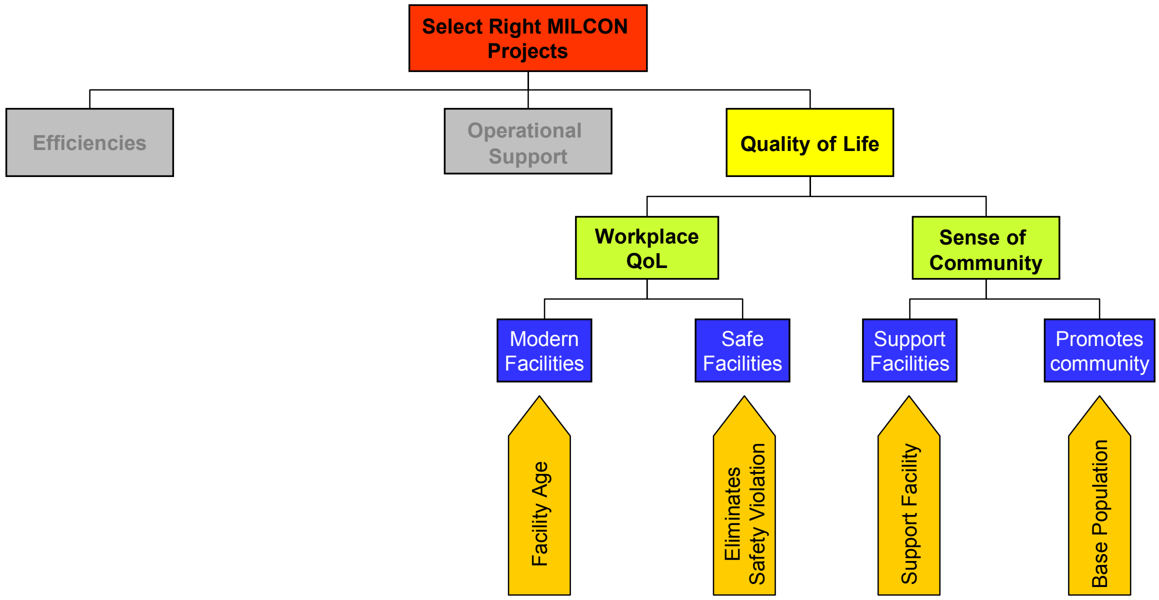


Figure 4.13: MILCON Hierarchy (Branch 3)

4.3.2 Step 2: Obtain Historical Data for Measures

The list of historical data may be found in Appendix D. This data includes the y-value scores after translation by the SDVFs, and the alternates are in rank ordered score (ranked by Dempsey's weighted hierarchy), for each of the 200 alternates.

4.3.3 Step 3: Develop Error Function

With only one time period, and no priority on matching up any rankings of alternates over others, the error function is:

$$\text{Min E} = \left(|\, Rank_{11}{}^{k} - Rank_{11}{}^{c} \,| + |\, Rank_{21}{}^{k} - Rank_{21}{}^{c} \,| + \ldots + |\, Rank_{200}{}^{k} - Rank_{200}{}^{c} \,|\right)$$

4.3.4 Step 4: Create Optimization

$$\text{Minimize } E = \sum_{j=period1}^{period1} \sum_{i=Alt1}^{Alt200} |\, Rank_{ij}{}^{k} - Rank_{ij}{}^{c} \,|$$

Subject to: $\sum W_{ij} = 1 \;\; \forall \;\; W_{(i+1),v} \in D_{ij}$ (the sum of all local weights = 1, i = 1,2,3,4,5)

$0 \le W_{i\,j} \le 1$ (all weights must be between zero and one)

Definitions for any of the above calculations may be reviewed in chapter 3.

4.3.5 Step 5: Solve for Optimal Weights

This step of the VFT process was done in Excel's Premium Solver. The response surface produced by the 19 measures, 27 values, and 200 alternates was rather large. Unlike the earlier example problems in Chapter 3, where Solver was able to quickly converge to the globally optimal solution, Solver found good results with each run, however the globally optimal solution of Error = 0 was never reached (Error = 0 if Dempsey's weights were inputted). Each run converged on a locally optimal solution, providing good weights for the hierarchy, but because the focus was too quickly narrowed into this local area of interest, Error = 0 was never found. A different genetic algorithm with more variable parameters such at crossover rate, would likely find the optimal solution, but the complexity of this response surface proved too difficult for Premium Solver's Evolutionary Solver. The solved weights for 50 independent runs may be found in Appendix E.

4.3.6 Step 6: Integrate Weights Into Hierarchy

Both the "known" and "calculated" weights are show below, for the sake of comparison. This run of "calculated" weights as chosen for their lowest absolute error in difference between "known" and "calculated" rankings of alternatives:

Major Dempsey's (known weights)

0.2000					0.5000									0.3000			
0.6000			0.4000		0.4500		0.1500				0.0500	0.3500		0.6000		0.4000	
0.6000	0.4000		0.5000	0.5000	0.5000	0.5000	0.1000	0.9000			1.0000	0.7000	0.3000	0.7000	0.3000	0.8000	0.2000
1.0000	0.3500	0.6500	1.0000	1.0000	1.0000	1.0000	1.0000	0.1000	0.3000	0.6000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.0720	0.0168	0.0312	0.0400	0.0400	0.1125	0.1125	0.0075	0.0068	0.0203	0.0405	0.0250	0.1225	0.0525	0.1260	0.0540	0.0960	0.0240

"Solved For" Weights

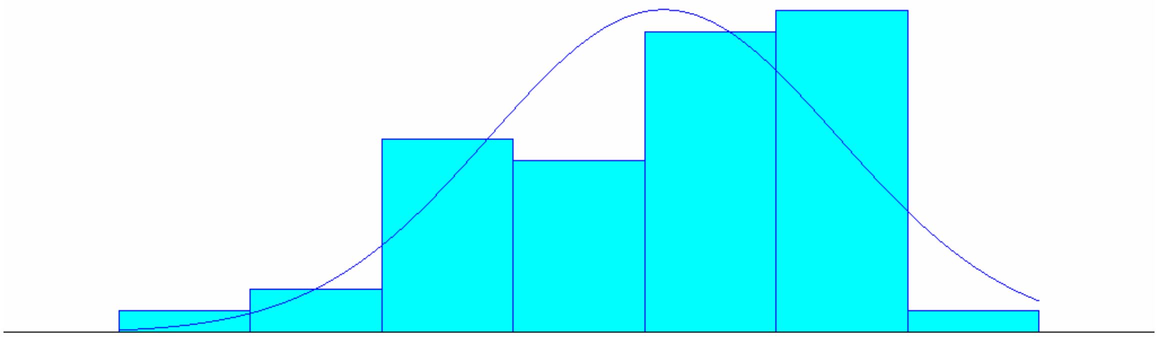
0.1658					0.5307									0.3014			
0.5210			0.4735		0.3857		0.1211				0.1035	0.3843		0.5530		0.4471	
0.6331	0.3668		0.5028	0.4955	0.5051	0.4955	0.0839	0.9165			1.0000	0.6743	0.3257	0.6756	0.3531	0.8459	0.1555
1.0000	0.4746	0.8811	1.0000	1.0000	1.0000	1.0000	1.0000	0.1063	0.2779	0.6124	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.0547	0.0150	0.0279	0.0395	0.0389	0.1034	0.1014	0.0054	0.0063	0.0164	0.0361	0.0549	0.1375	0.0664	0.1126	0.0589	0.1140	0.0210

Figure 4.14: Known and Calculated Weights (Example 2)

4.3.7 Summary of Findings From Example 2

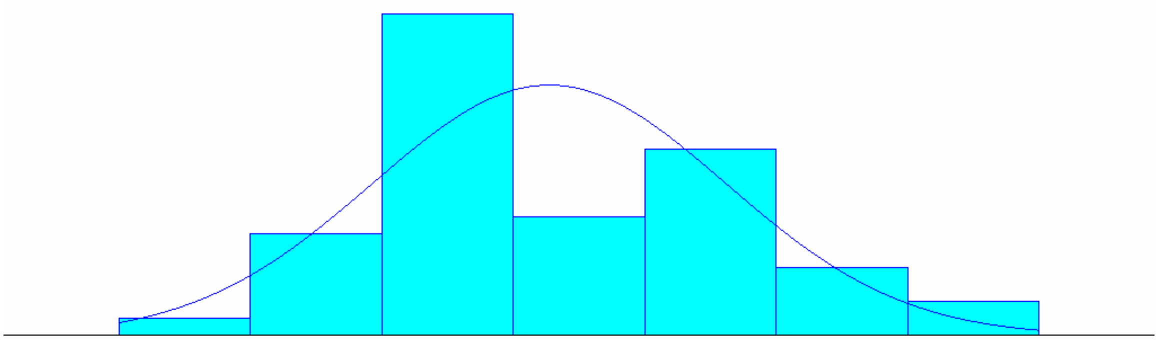
Although Solver never converged on Error = 0, the derived weights for the hierarchy came very close to the true weights that Dempsey used to score the alternates. At a minimum, they would provide an analyst such as Dempsey with an excellent "first cut" at the process of weighting the hierarchy. As can be seen in Figure 4.9, the derived weights at each tier showed progression in accuracy with each tier. It is also important to see that the relative weights at each tier were proportionally correct (i.e. tier 1- Value 2 > Value 3 > Value 1). At the tier of measures, the total absolute error between known and derived weights is only .153. This shows valuable insight into the process.

As in Example 1, the distribution of the weights over fifty runs proved to be normal, and the weights from the different runs fall very close to the mean. Histograms showing the distributions around the first tier of values are:



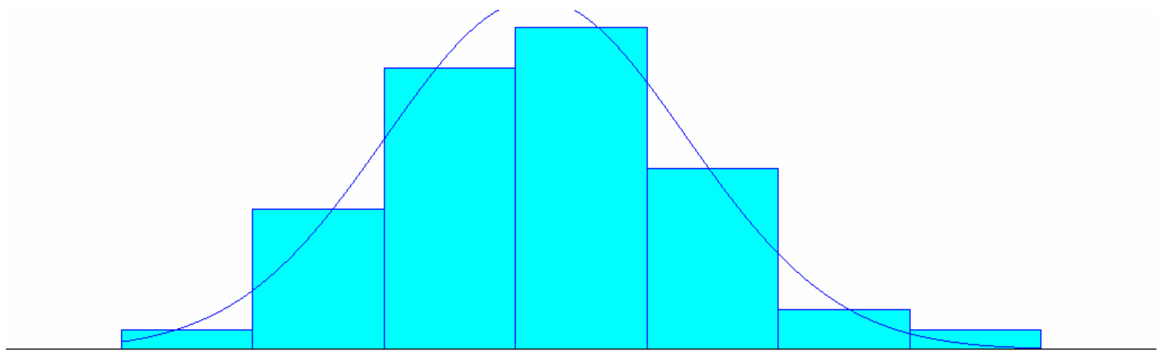
Distribution: Normal
Expression: NORM(0.256, 0.0341)
Square Error: 0.029198

Figure 4.15: Distribution of Weights (Efficiencies Value)



Distribution: Normal
Expression: NORM(0.443, 0.0384)
Square Error: 0.040188

Figure 4.16: Distribution of Weights (Operational Support Value)



Distribution: Normal
Expression: NORM(0.3, 0.018)
Square Error: 0.000595

Figure 4.17: Distribution of Weights (Quality of Live Value)

4.4 Summary

This chapter has shown a large-scale, real world implementation of using optimization to select the weights for a VFT hierarchy. The results were positive taking into consideration the huge response surface created, and the inability to customize the GA portion of the Solver to meet the needs of this solution space. This implementation has given an idea of the diverse purposes this methodology could be used for, and the insight the results can provide.

Chapter 5. Discussion

5.0 Introduction

This chapter briefly summarizes the proposed optimization based methodology for determining the weights of a value focused thinking hierarchy. The limitations of this methodology will be discussed, and recommendations will be made for future research in this area.

5.1 Conclusions

Value Focused Thinking is a strong, growing subset of Decision Analysis. This strategic way of making difficult decisions has set the standard in multiple industries. One of the major drawbacks of VFT, however, is the great amount of time and effort it takes by decision makers and/or subject matter experts to provide insight into the process being studied. This is especially true when determining the appropriate weights for a hierarchy. Conventional weighting techniques often require unrealistic time demands on these DMs/SMEs, especially in circumstances necessitating high ranking military officers, heads of businesses, etc… When historical data permits, this step of the VFT process can be greatly reduced, or even omitted, by solving for the historically optimal weights, that minimize an error function based on the difference between known and predicted performance. Depending on the complexity of the process, and size of the solution space, the process can provide optimal weights for the hierarchy, or at a minimum, a far superior starting point for the discussion on weighting, hence reducing the time demands on the DMs/SMEs.

5.1 Limitations

The methodology explored in this thesis proved to be very successful. Great insight was gained into the MILCON process by using available historical information. This use of past knowledge, combined with modern optimization techniques, was able to provide information into how MILCON projects were prioritized by a panel (by knowing the relative tradeoffs in values of the hierarchy). When this methodology was tested on the MILCON example with "known" weights, beneficial information into these tradeoffs was also gained, despite never converging on the perfect weights.

Frontline's Genetic/Evolutionary Algorithm Solver was the optimization package used due to the benefits it showed for this particular methodology. By combining a genetic/evolutionary algorithm with standard linear and non-linear program, the solution space was best explored. The chaotic nature of many real world problems, such as the MILCON example in Chapter 4, require a tool such as a GA to provide quality results. This tool easily converged on "known" optimal weights of many dummy problems, both small and large. Unfortunately in the case of the MILCON example, the response surface proved to be too large and chaotic for Premium Solver. Optimality was never reached, not due to a problem with the methodology, but due to the limitations of the optimization package. The "tweaking" of the GA in Solver is tightly controlled, not allowing enough exploration of the solution space before converging on a local minimum. This in turn limited the success of the optimization, and furthermore detracted from the success of this methodology.

5.2 Future Research

Ones success using this methodology on very large problems would greatly increase by using a more user defined genetic algorithm. The freedoms provided by this will allow you to tailor the GA to the needs of your response surface. Future research could be focused in this area, as well as closely looking at the effects size of the hierarchy and number of time periods have on the success of the process.

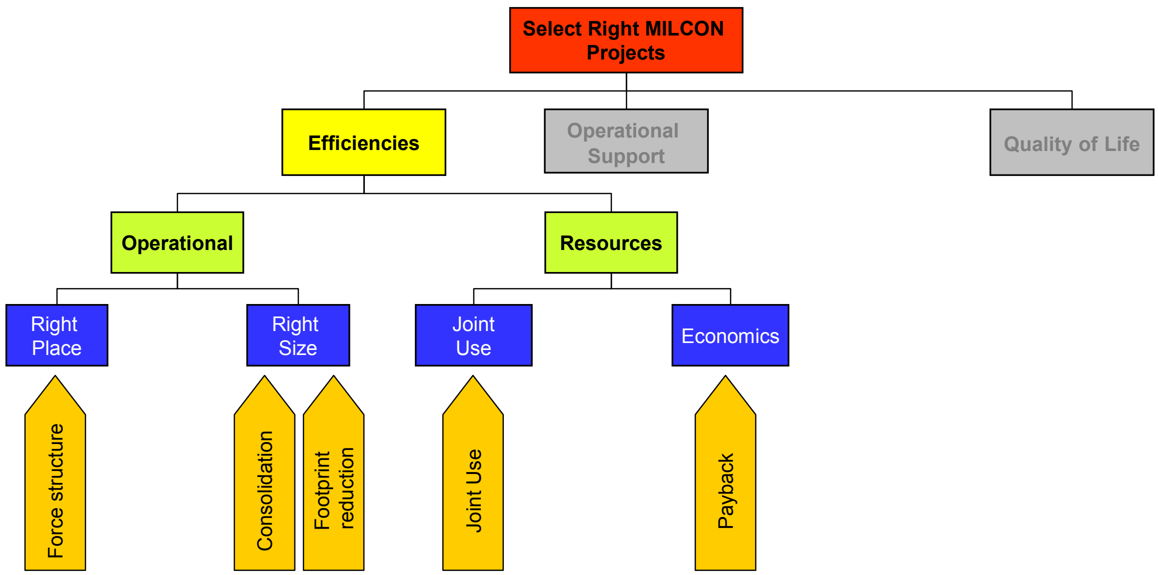
5.4 Summary

The proposed methodology provides a beneficial weighting scheme for a VFT hierarchy when input from DMs/SMEs is limited or unavailable. This application provides the VFT community with a new way to weight a hierarchy, when conventional methods are not possible. Using this methodology, instead of making the mistake that George Santayana warns against, "Those who ignore history are doomed to repeat it", we can use our knowledge of the past to provide insight into the future, and hope the history indeed repeats itself.

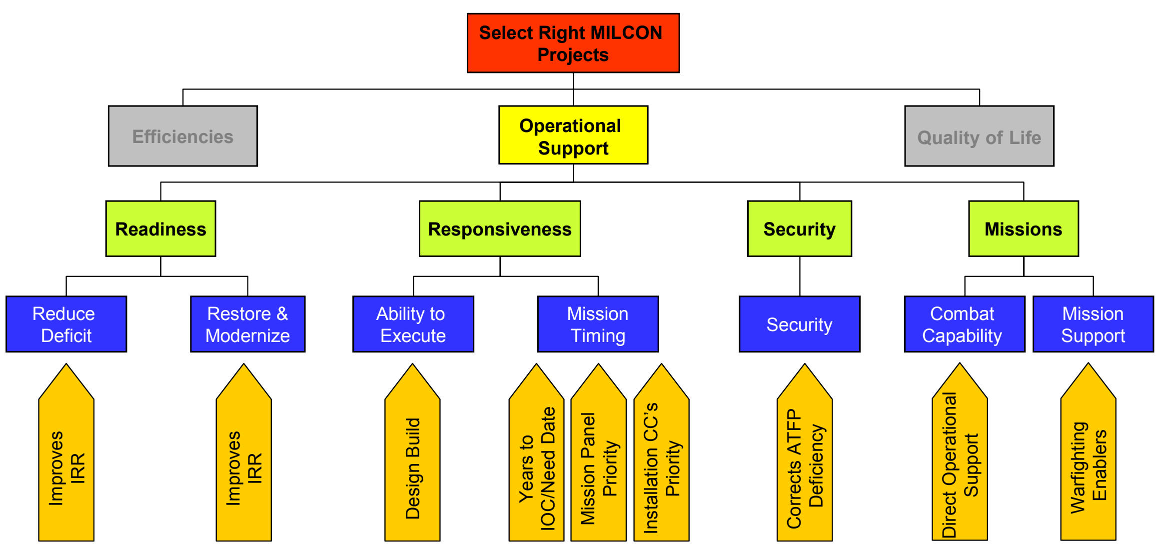
Appendix A

This appendix shows the individual tiers of the MILCON hierarchy.

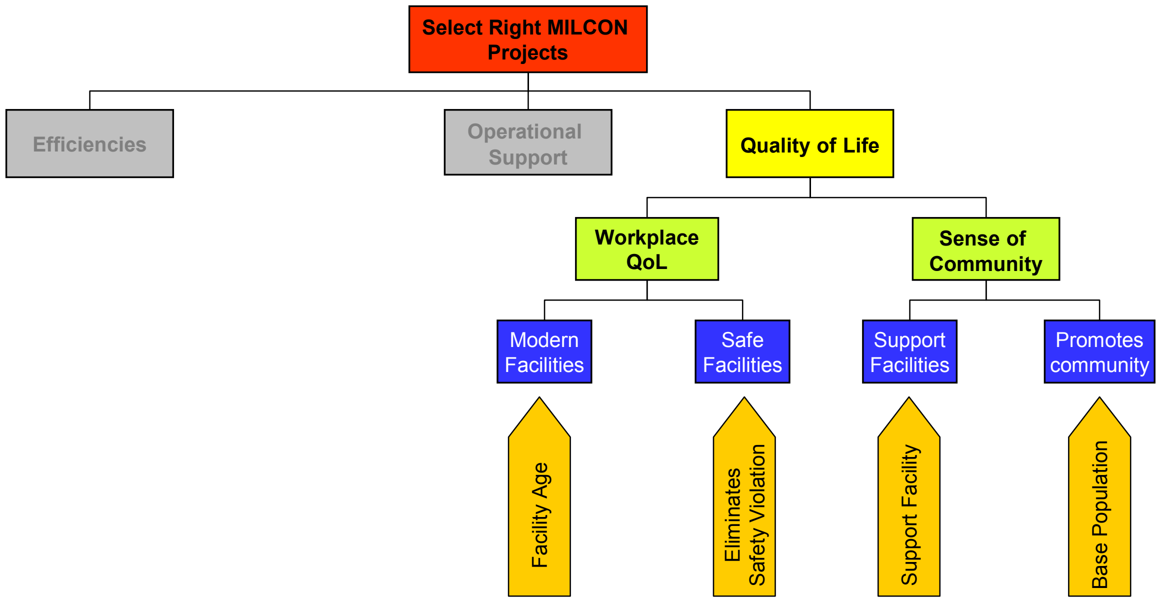
First Tier of Hierarchy



Second Tier of Hierarchy



Third Tier of Hierarchy



Appendix B

This appendix contains the data for the measures of the MILCON hierarchy:

Force Structure	Consolidation	Footprint Reduction	Joint Use	Payback	Deficit IRR	Restoration and Modernization IRR	Design Build	Years to IOC	Mission Panel Points	Installation CC Priority Points	Corrects ATFP Deficiency	Direct Support	Warfighting Enabler	Avg Facility Class	Eliminates Safety	Support Facility	Base Population
1	1	1	0	0	0	0.3	0	1	0.167	1	0	1	0	0.896	0	0	0
0	0	1	0	1	0	1	0	1	1	1	0	1	0	0.299	0	0	0.8
0	1	0	0	0	0	0.8	0	0	0.143	1	0	0	0	0.507	0	1	1
1	0	1	0	0	0	1	0	1	1	1	0	1	0	0.373	0	0	1
0	1	0.7	0	0	0	0.8	1	1	0.5	1	0	1	0	0.786	0	0	1
0	0	0	0	0	0	0.8	0	0	0.125	1	0	1	0	0.422	0	0	0.3
0	0	0	0	0	0	1	0	0	1	1	0	0	0	0.515	0	1	0.8
0	1	0.7	0	0	0	1	0	0	0.5	0.5	0	1	0	0.373	0	0	0.8
0	1	0	0	0	0	1	1	0	1	1	0	0	0	0.841	0	1	0.5
0	1	0	0	0	0	0.8	0	0	0.111	1	0	1	0	0.313	0	0	0.8
0	1	0	0	0	0	0.8	0	0	0.25	1	0	0	0	0.501	0	1	0.5
0	1	0	1	0	0	0.8	0	0	0.25	1	0	0	0	0.94	0	1	0.3
1	1	0	0	0	0.8	0	1	1	0.111	0.5	0	0	0	0.518	0	1	1
1	1	0	0	0	0	1	0	0	0.333	1	0	1	0	0.289	0	0	1
0	1	1	0	0	0	0.8	0	0	0.1	1	0	1	0	0.575	0	0	0.5
1	1	0	1	0	1	0	0	1	0.5	1	0	0	1	0.687	0	0	0.5
1	1	0	0	0	0.3	0	0	1	0.1	1	0	0	0	0.392	0	1	0.5
0	1	1	0	0	0	1	0	0	1	1	0	0	1	0.701	0	0	0.8
0	1	1	1	0	0	0.8	1	0	1	1	0	0	0	0.368	0	1	0.3
0	1	1	0	0	0	0.3	0	0	0.056	1	0	0	0	0.806	0	1	0
0	0	0.7	0	0	0	0.3	0	0	0.053	1	0	1	0	0.612	0	0	0.3
0	0	0	0	1	0	0.8	1	0	0.5	1	0	0	0	0.627	0	1	0.3
0	0	0	0	0	0	0.8	0	0	0.5	1	0	0	0	0.354	0	1	0.8
0	1	1	0	0	0	0.8	1	0	0.2	1	0	0	0	0.612	0	1	0.3
0	1	0	0	0	0	1	0	0	0.25	1	0	1	0	0.703	0	0	1
0	1	0.7	0	0	0	0	1	0	0.042	1	0	0	0	0.716	0	1	1
0	0	0	0	0	0	0.8	0	0	0.333	1	0	0	0	0.929	0	1	0.5
0	1	1	0	0	0	0.3	0	0	0.167	1	0	0	0	0.224	0	1	1
0	1	1	0	0	0	0.8	1	0	0.25	1	0	0	0	0.538	0	1	0.8
0	0	0	0	0	0	0.8	0	0	0.091	0.5	0	0	0	0.597	0	1	0.5
0	0	0	0	0	0	1	0	0	0.5	1	0	1	0	0.672	0	0	0
0	1	0.7	0	0	0	1	0	0	0.143	1	0	0	0	0.687	0	1	0
0	0	0	0	0	0	1	0	0	0.5	1	0	0	0	0.638	0	1	0.8
0	1	0.7	0	0	0	0.8	0	0	0.083	1	0	1	0	0.621	0	0	1
0	1	1	0	0	0	0.8	0	0	0.077	1	0	0	0	0.706	0	1	0.8
0	0	0.7	0	0	0	0.8	0	0	0.083	0.5	0	0	0	0.687	0	1	0
0	1	1	0	0	0	0.3	1	0	0.143	1	0	1	0	0.657	0	0	0.5
0	1	1	0	0	0	1	1	0	0.04	0.5	0	1	0	0.527	0	1	0.8
0	1	0.7	0	0	0	0.8	0	0	0.071	1	0	0	0	0.597	0	1	0
0	0	0	0	0	0	1	0	0	1	1	0	0	0	0.388	0	1	0.5
0	1	0.7	0	0	0	0.8	0	0	0.2	0.5	0	0	0	0.716	0	1	1
0	1	1	0	0	0	0.3	0	0	0.067	1	0	0	0	0.866	0	1	0.5

0	0	0.7	0	0	0	1	0	0	0.091	0.5	0	0	0	0.448	0	1	1
0	0	0	0	0	0	0.8	1	0	0.2	0.5	0	0	0	0.627	0	1	0.3
0	1	1	1	0	0	0.3	0	0	0.048	1	0	0	0	0.313	0	1	0.5
0	0	0	0	0	0	0.3	0	0	0.125	1	1	0	0	0.597	0	1	1
0	1	0.7	0	0	0	0.8	1	0	0.077	1	0	0	0	0.642	0	1	0.5
0	1	0.7	0	0	0	0	0	0	1	0.333	0	0	0	0.701	0	1	1
0	0	0	0	0	0	0.8	1	0	0.167	0.333	0	0	0	0.49	0	1	0.3
0	1	1	0	0	0	0.8	0	0	0.033	1	0	1	0	0.194	0	0	0.5
0	0	0.7	0	0	0	0.8	1	0	0.143	1	0	0	0	0.467	0	1	0.8
0	1	0	0	0	0	1	0	0	0.083	1	0	1	0	0.642	0	0	0
0	0	0	0	0	0	0.8	0	0	0.067	0.333	0	1	0	0.746	0	0	0.8
0	1	1	0	0	0	0.8	0	0	0.143	1	0	0	0	0.441	0	1	0.5
0	0	0	0	0	0	0.8	0	0	0.071	1	0	0	0	0.672	0	1	0.5
0	1	1	0	0	0	1	0	0	0.2	1	0	1	0	0.701	0	0	1
0	1	0.7	0	0	0	1	0	0	0.2	0.5	0	0	0	0.582	0	1	0.8
0	0	0.7	1	1	0	0.3	1	0	0.125	0.5	0	0	0	0.532	0	1	1
0	1	0	0	0	0	0.3	1	0	0.111	0.333	0	1	0	0.746	0	0	1
0	0	0	0	1	0	0.8	0	0	0.25	0.5	0	0	0	0.194	0	1	0.8
0	1	1	0	0	0	1	0	0	0.038	1	0	1	0	0.597	0	0	0
0	1	0.7	0	0	0	0.3	1	0	0.014	1	0	1	0	0.532	0	0	0.8
0	0	0	0	0	0	1	0	0	0.125	1	0	0	0	0.261	0	1	0
0	1	0	1	0	0	1	0	0	0.333	0.25	0	0	1	0.418	0	0	0.5
0	1	0	0	0	0	1	0	0	0.077	0.5	0	0	0	0.466	0	1	0.5
0	1	0.7	0	0	0	1	0	1	0.167	0.5	0	0	0	0.645	0	1	0.8
0	1	1	0	0	0	1	1	0	0.038	0.25	0	0	0	0.402	0	1	0.3
0	1	0	0	0	0	0.8	0	0	0.032	0.5	0	1	0	0.529	0	0	0.8
0	1	0.7	0	0	0	1	1	0	0.111	0.5	0	0	1	0.313	0	0	0.3
0	1	0.7	0	0	0	0.3	0	0	0.014	0.5	0	1	0	0.532	0	0	0.8
0	0	1	0	0	0	1	0	0	0.5	0.5	0	0	0	0.634	0	1	1
0	0	0	0	0	0	0.3	1	0	0.111	0.25	0	0	0	1	0	1	1
0	0	1	0	0	0	1	0	0	0.1	1	0	0	0	0.597	0	1	0
0	1	1	0	0	0	0.8	0	0	0.063	0.333	0	1	0	0.337	0	0	0.8
0	1	0.7	0	0	0	0.3	1	0	0.048	0.5	0	0	0	0.672	0	1	0.3
0	1	0	0	0	0	0.8	0	0	0.059	0.5	0	0	0	0.501	0	1	0.5
0	1	0.7	0	0	0	0.8	0	0	0.02	0.5	0	1	0	0.271	0	0	0.5
0	0	0	0	0	0	1	0	0	0.071	1	0	1	0	0.216	0	0	0.3
0	1	0	0	0	0	0.3	0	0	0.125	0.25	0	1	0	0.607	0	0	1
0	0	0	0	0	0	0.8	1	0	0.037	0.333	0	0	0	0.496	0	1	0.8
0	1	0.7	0	0	0	0.3	0	0	0.02	0.5	0	1	0	0.593	0	0	0.5
0	0	0	0	0	0	0.8	0	0	0.02	1	0	1	0	0.811	0	0	1
0	0	0	0	0	0	0.8	0	0	0.063	0.25	0	1	0	0.552	0	0	0.8
0	1	0	0	0	0	0.3	1	0	0.045	0.2	0	0	0	0.925	0	1	1
0	0	0	0	0	0	1	1	0	0.037	1	0	1	0	0.381	0	0	1
0	1	0	0	0	0	1	0	0	0.025	1	0	1	0	0.433	0	0	0.8
0	1	0.7	0	0	0	0.8	1	0	0.036	0.5	0	0	0	0.259	0	1	0.5
0	0	0.7	0	0	0	1	0	0	0.091	0.25	0	0	0	0.515	0	1	0.8
0	1	0.7	0	0	0	0.8	0	0	0.056	0.2	0	0	0	0.487	0	1	1
0	0	0	1	0	0	0.3	1	0	0.1	0.333	0	1	0	0.414	0	0	1
0	1	1	0	0	0	1	0	0	0.037	1	0	0	0	0.701	0	1	0
0	1	0.7	0	0	0	0.8	0	0	0.02	1	0	1	0	0.484	0	0	0.5
0	1	0	0	0	0	0.8	0	0	0.026	1	0	0	0	0.632	0	1	0.5

0	1	0.7	0	0	0	1	1	0	0.036	0.5	0	1	0	0.467	0	0	1
1	0	0.7	0	0	0	0.3	0	0	0.03	0.5	0	1	0	0.483	0	0	1
0	1	0.7	0	0	0	1	0	0	0.036	1	0	1	0	0.03	0	0	0
0	0	0.7	0	0	0	0.8	1	0	0.019	0.333	0	0	0	0.418	0	1	1
0	1	0.7	0	0	0	1	0	0	0.034	1	0	1	0	0.239	0	0	0.5
0	0	0	0	0	0	0.8	0	0	0.034	0.5	0	0	0	0.642	0	1	0.3
0	0	0	0	0	0	0.8	0	0	0.019	0.2	0	1	0	0.669	0	0	0.5
0	0	0	0	1	0	0.3	1	0	0.014	0.333	0	0	0	0.578	0	1	1
0	0	0.7	0	0	0	1	1	0	0.024	0.25	0	1	0	0.687	0	0	0.8
0	1	0.7	0	0	0	1	0	0	0.083	1	0	0	0	0.808	0	1	0.3
0	0	0	0	1	0	0.8	0	0	0.019	1	0	1	0	0.672	0	0	0.3
0	0	1	0	0	0	1	0	0	0.167	0.5	0	0	0	0.505	0	1	1
0	0	1	0	0	0	0.8	0	0	0.033	0.5	0	0	0	0.761	0	1	0.5
0	1	0.7	0	0	0	1	0	0	0.333	1	0	1	0	0.403	0	0	0.5
0	1	0	0	0	0	0.8	0	0	0.018	0.333	0	1	0	0.642	0	0	0.5
0	1	0	0	0	0	0.8	0	0	0.018	1	0	0	0	0.94	0	1	0.8
0	1	0	0	0	0	0.8	0	0	0.032	0.5	0	0	0	0.664	0	1	0.5
0	0	0.7	0	0	0	0.3	0	0	0.063	0.333	0	0	0	0.687	0	1	1
0	1	0	0	0	0	1	0	0	0.033	0.5	0	1	0	0.104	0	0	0.5
0	0	0	0	0	0	1	0	0	0.032	0.333	0	1	0	0.612	0	0	1
0	1	0	0	0	0	0.3	0	0	0.043	1	0	0	0	0.567	0	1	0.5
0	1	0	0	0	0	1	0	0	0.059	1	0	0	0	0.209	0	1	0.3
0	1	0	0	0	0	1	0	0	0.024	0.2	0	1	0	0.25	0	0	0.5
0	1	0.7	0	0	0	1	0	0	0.023	1	0	0	0	0.552	0	1	0
0	1	0.7	1	0	0	0.3	0	1	0.013	0.5	0	0	0	0.351	0	1	0
0	1	1	0	0	0	0.3	0	0	0.042	0.5	0	0	0	0.565	0	1	1
0	1	0	0	0	0	1	0	0	0.023	1	0	1	0	0.445	0	0	0.5
0	1	0	0	0	0	1	0	0	0.031	0.5	0	1	0	0.448	0	0	1
0	1	0	0	0	0	1	0	0	0.03	0.25	0	1	0	0.394	0	0	1
0	0	1	0	0	0	0.8	0	0	0.018	0.2	0	1	0	0.119	0	0	1
1	0	0	0	0	0	0.3	0	1	0.013	0.333	0	0	0	0.493	0	1	0.5
0	0	1	0	0	0	1	0	0	0.077	0.5	0	0	0	0.612	0	1	0.8
0	1	0	0	0	0	0.8	0	0	0.063	0.5	0	0	0	0.272	0	1	0.5
0	1	0.7	0	0	0	0	0	0	0.143	0.333	0	1	0	0.639	0	0	0.5
0	1	0	0	0	0	1	0	0	0.029	0.5	0	1	0	0.361	0	0	1
0	1	1	0	0	0	0.8	0	0	0.031	0.333	0	0	0	0.493	0	1	0.5
0	1	0	0	0	0	0.8	0	0	0.017	0.167	0	0	0	0.332	0	1	1
0	0	1	0	0	0	1	0	0	0.029	0.5	0	0	0	0.672	0	1	0.5
0	0	0.7	0	0	0	0.8	1	0	0.017	0.333	0	0	0	0.313	0	1	0.3
0	1	0	0	0	0	0.8	0	0	0.026	0.25	0	1	0	0.306	0	0	1
0	0	0	0	0	0.8	0	0	1	0.011	0.5	0	1	0	0.433	0	0	0.5
0	1	0	0	0	0	1	0	0	0.071	0.333	0	0	0	0.603	0	1	0.5
0	0	0	0	0	0	1	0	0	0.056	0.333	0	0	0	0.284	0	1	1
0	0	0	0	0	0	1	0	0	0.053	0.333	0	0	0	1	0	1	0.3
0	1	0	0	0	0	1	0	0	0.028	0.167	0	1	0	0.394	0	0	1
0	1	0.7	0	0	0	0.8	0	0	0.017	0.333	0	1	0	0.496	0	0	0.5
0	1	0	0	0	0	0.8	0	0	0.025	0.2	0	1	0	0.507	0	0	1
0	0	0	0	0	0	0.3	0	0	0.028	1	0	1	0	0.836	0	0	0.8
0	0	1	0	0	0	1	0	0	0.034	0.25	0	0	0	0.254	0	1	0.8
0	0	0	0	0	0	0.3	0	0	0.043	1	0	1	0	0.619	0	0	0
0	0	0	0	0	0	0.8	0	0	0.053	0.5	0	1	0	0.463	0	0	0.5

0	1	0	0	0	0	0.8	0	0	0.024	0.25	0	1	0	0.567	0	0	0.5
1	1	0	0	0	0	0.8	0	1	0.024	0.333	0	0	0	0.134	0	1	0
0	1	0	0	0	0	0.3	0	0	0.013	0.5	0	1	0	0.687	0	0	0.5
0	1	0	0	0	0	0.3	1	0	0.012	1	0	0	0	0.672	0	1	1
0	0	0	0	0	0	1	0	0	0.05	1	0	0	0	0.493	0	1	0.5
0	0	0	0	0	0	0.8	0	0	0.143	1	0	0	0	0.716	0	1	0
0	1	1	0	0	0	0.3	0	0	0.027	1	0	0	0	1	0	1	0.5
0	1	0	0	0	0	1	0	0	0.027	0.25	0	1	0	0.836	0	0	0.5
0	0	0	0	0	0	0.8	0	0	0.05	0.5	0	0	0	0.664	0	1	0.3
0	1	0	0	0	0	0.8	0	0	0.059	0.5	0	0	0	0.936	0	1	0.8
0	0	0	0	0	0	1	0	0	0.067	0.25	0	1	0	1	0	0	1
1	1	0	0	0	0	0.8	0	0	0.056	0.333	0	0	0	0.936	0	1	0.8
0	1	0	0	0	0	0.8	0	0	0.016	1	0	1	0	1	0	0	0.8
0	0	0	0	0	0	0.3	0	0	0.045	0.5	0	0	0	0.866	0	1	0.5
0	0	0.7	0	0	0	0.8	0	0	0.016	0.333	0	0	0	0.687	0	1	0.5
0	0	0.7	0	0	0	0.8	0	0	0.023	0.333	0	1	0	0.609	0	0	0.5
0	0	0	0	0	0	1	0	0	0.048	1	0	0	0	0.716	0	1	0.5
0	0	0.7	0	0	0	0.3	0	0	0.019	1	0	1	0	0.687	0	0	0.5
0	0	0.7	0	0	0	0.8	0	0	0.016	0.5	0	0	0	0.433	0	1	0.5
0	1	1	0	0	0	1	0	0	0.333	0.333	0	0	0	0.44	0	1	0.5
0	0	0	0	0	0	0	0	0	0.018	1	0	1	0	1	0	0	0
0	0	0	0	0	0	1	0	0	0.045	1	0	0	0	0.633	0	1	0
0	0	0	0	0	0	0.8	0	0	0.023	1	0	1	0	0.313	0	0	0.5
0	0	0	0	0	0	0.8	0	0	0.016	0.333	0	1	0	0.493	0	0	0.5
0	0	0	0	0	0	1	0	0	0.022	0.5	0	1	0	0.767	0	0	1
0	0	0	0	0	0	1	0	0	0.25	0.5	0	1	0	0.477	0	0	0.5
0	0	0	0	0	0	0.8	0	0	0.059	0.5	0	1	0	0.893	0	0	0.8
0	0	0	0	0	0	0.8	0	0	0.015	0.333	0	1	0	0.687	0	0	0.8
0	0	0	0	0	0	0.8	0	0	0.022	0.2	0	1	0	0.54	0	0	0.5
0	0	0	0	0	0	1	0	0	0.043	0.143	0	0	0	0.373	0	1	0.8
0	0	0	0	0	0	0.8	0	0	0.015	0.25	0	0	0	0.507	0	1	0.8
0	0	0	0	0	0	0.8	0	0	0.022	0.5	0	1	0	0.627	0	0	0.5
0	0	0	0	0	0	0.8	0	0	0.015	0.333	0	1	0	0.536	0	0	0.5
0	0	0	0	0	0	0.8	0	0	0.014	0.2	0	1	0	0.696	0	0	0.8
0	0	0	0	0	0	1	0	0	0.021	0.333	0	1	0	0.767	0	0	1
0	0	0	0	0	0	0.8	0	0	0.014	0.167	0	1	0	0.522	0	0	0.5
0	0	0	0	0	0	0.8	0	0	0.021	0.333	0	1	0	0.627	0	0	0.8
0	1	1	0	0	0	0.3	1	0	0.083	0.333	1	0	0	0.716	0	1	0.3
0	0	0	0	0	0	1	0	0	0.333	0.5	0	0	0	0.896	0	1	0
0	0	0	0	0	0	1	0	0	0.042	0.25	0	0	0	0.567	0	1	0.8
0	0	0	0	0	0	1	0	0	0.04	0.333	0	0	0	0.322	0	1	0.5
0	1	0	0	0	0	0.8	0	0	0.053	0.25	1	0	0	0.898	0	1	1
0	0	0	0	0	0	0.8	0	0	0.021	0.5	0	1	0	0.866	0	0	0
0	1	0.7	0	0	0	1	0	0	0.038	0.2	0	0	0	0.522	0	1	1
0	1	1	0	0	0	1	0	0	0.067	0.25	0	0	0	0.463	0	1	0.5
0	0	0	0	0	0	1	0	0	0.021	1	0	0	0	0.552	0	1	0
0	0	0.7	0	0	0	0.3	0	0	0.026	0.333	0	0	0	0.716	0	1	0.8
0	1	0	0	0	0	0.8	0	0	0.05	0.25	0	0	0	0.657	0	1	0.5
0	0	0	0	0	0	0.8	0	0	0.029	0.333	0	0	0	0.851	0	1	0
0	0	0	0	0	0	0	0	0	0.067	0.333	1	0	0	1	0	1	0.5
0	0	0	0	0	0	0	0	0	0.063	0.25	1	0	0	1	0	1	0.5
0	0	1	0	0	0	0.8	0	0	0.014	0.2	0	1	0	0.547	0	0	0.8

Appendix C

This appendix contains the output from 50 runs of the model:

	Average	1	2	3	4	5	6
Force Structure	0.0299628	0.013771	0.012668	0.066181	0.046262	0.023875	0.011032
Consolidation	0.0209869	0.008476	0.035995	0.013682	0.031062	0.014375	0.011953
Foorprint Reduction	0.023668	0.006448	0.029903	0.096293	0.048155	0.016201	0.018491
Joint Use	0.0258702	0.018455	0.037726	0.066854	0.029732	0.013522	0.006973
Payback	0.0574659	0.033835	0.075233	0.099812	0.073895	0.053317	0.049886
Deficit IRR	0.1459364	0.165428	0.129895	0.031241	0.060004	0.17104	0.191052
Rest. & Modern. IRR	0.0180274	0.007361	0.028327	0.052092	0.08649	0.01082	0.008198
Design Build	0.0282878	0.030229	0.030829	0.018915	0.050161	0.023478	0.032524
Years to IOC/Need date	0.0119944	0.009517	0.025437	0.020797	0.031564	0.003525	0.019844
Mission Pannel Points	0.0410921	0.051544	0.0138	0	0.021059	0.035642	0.033016
Installation CC's Priority	0.0798081	0.079206	0.086934	0.043621	0.043709	0.090385	0.113823
Corrects ATFP Deficiency	0.1031996	0.169137	0.073451	0.083333	0.107422	0.146681	0.004105
Direct Operational Support	0.0715769	0.087958	0.060672	0.067334	0.0636	0.066631	0.085958
Warfighting Enablers	0.0897665	0.08448	0.096481	0.015999	0.082893	0.084823	0.113098
Facility Age	0.0560299	0.05432	0.044055	0.134668	0.052039	0.051106	0.064406
Eliminates Safety Violation	0.0378305	0.022137	0.042893	0.098678	0.074675	0.014982	0.012783
Support Facility	0.0791751	0.0825	0.059018	0.096662	0.070424	0.075961	0.093507
Base Population	0.0333885	0.016527	0.05509	0.070005	0.049441	0.040847	0.042238
Error	7710.32	7118	8172	9582	9360	7324	7432
Efficiencies		0.107518	0.225925	0.333333	0.213367	0.133527	0.1138
op suppt		0.684252	0.545892	0.333333	0.546903	0.632738	0.601068
QOL		0.205521	0.228203	0.333333	0.23973	0.233574	0.285132
operational		0.513717	0.500018	0.5	0.514324	0.500055	0.5
resources		0.48631	0.500013	0.5	0.485676	0.499964	0.5
readiness		0.252496	0.28985	0.25	0.26786	0.287406	0.331837
responsiveness		0.248647	0.28763	0.25	0.26786	0.240186	0.33081
security		0.247185	0.134552	0.25	0.196419	0.23182	0.00683
missions		0.251798	0.287872	0.25	0.26786	0.240214	0.33081
work QOL		0.517198	0.500003	0.5	0.5	0.500246	0.524153
sense of community		0.481837	0.500011	0.5	0.5	0.499968	0.475847
right place		0.24933	0.112142	0.397085	0.421558	0.357567	0.193891
right size		0.750879	0.887827	0.602915	0.578442	0.642226	0.806109
joint use		0.352958	0.333964	0.401127	0.286911	0.202548	0.122548
econ		0.647094	0.665981	0.598873	0.713089	0.798657	0.876722
reduce deficit		0.957499	0.820941	0.374892	0.4096	0.94054	0.957862
restore and mondernize		0.042604	0.179026	0.625108	0.5904	0.059501	0.0411
ability to execute		0.177672	0.196343	0.226985	0.342413	0.154486	0.163568
mission timing		0.822408	0.803664	0.773015	0.657587	0.851051	0.836605
combat capability		0.510514	0.386083	0.808009	0.434151	0.438381	0.432297
mission support		0.490324	0.613954	0.191991	0.565849	0.558071	0.568789
modern facilities		0.511027	0.386103	0.808009	0.434151	0.437388	0.430945
safe facil		0.208262	0.375917	0.592069	0.622995	0.128224	0.085531
support facilities		0.833098	0.517225	0.579973	0.587526	0.650462	0.689178
promotes community		0.166895	0.482805	0.420027	0.412474	0.349776	0.311306
Consolidation		0.204378	0.358897	0.136158	0.489336	0.33523	0.260601
Foorprint Reduction		0.155482	0.298156	0.958276	0.758602	0.377816	0.403146
Years to IOC/Need date		0.068019	0.201585	0.322838	0.327657	0.027254	0.119289
Installation CC's Priority		0.566071	0.688933	0.677162	0.453734	0.698827	0.684241
Mission Panel Points		0.368376	0.109363	0	0.218609	0.275571	0.198472

7	8	9	10	11	12	13	14	15
0.03909	0.036583	0.064541	0.004855	0.010208	0.029324	0.014956	0.012741	0.037597
0.06556	0.043255	0.009378	0.010816	0.023096	0.018555	0.011196	0.001237	0.014011
0.056681	0.00923	0.028119	0.010954	0.026821	0.013791	0.015552	0.011296	0.025083
0.039667	0.05847	0.027817	0.009031	0.032244	0.032137	0.019276	0.005009	0.030808
0.093717	0.072911	0.040293	0.015924	0.055931	0.061989	0.031989	0.026362	0.066863
0.070761	0.086735	0.10768	0.20486	0.149012	0.167996	0.1738	0.191983	0.146495
0.045855	0.031884	0.042675	0.000813	0.001279	0.009154	0.011264	0.005784	0.010456
0.053793	0.040649	0.053727	0.028972	0.019106	0.026972	0.029915	0.03844	0.025722
0.022196	0.015958	0.002575	0.053254	0.008781	0.00835	0.004765	0.026955	0.008284
0.000616	0	0.051508	0.052781	0.055883	0.044562	0.06969	0.044782	0.015912
0.040012	0.062011	0.042545	0.071723	0.067066	0.095916	0.077014	0.08662	0.10715
0.116616	0.118619	0.150355	0.1148	0.137608	0.023351	0.126277	0.113342	0.060142
0.054867	0.061879	0.063745	0.078005	0.068732	0.084088	0.06788	0.092553	0.072354
0.061749	0.05674	0.08661	0.127494	0.081433	0.092594	0.114376	0.104551	0.08468
0.067811	0.068537	0.04701	0.040244	0.051334	0.062457	0.042412	0.054399	0.064967
0.09573	0.063724	0.031934	0.012919	0.027116	0.021014	0.016423	0.012822	0.01601
0.080407	0.086676	0.096481	0.079003	0.071241	0.0962	0.07549	0.090512	0.076906
0.042233	0.044706	0.014403	0.025014	0.029203	0.027231	0.032056	0.025247	0.052247
9174	8770	8486	7622	7396	7262	7306	7338	7618
0.266768	0.262762	0.176813	0.056695	0.197957	0.1894	0.103207	0.062747	0.198694
0.466465	0.474476	0.60142	0.731776	0.588804	0.553243	0.674932	0.70487	0.531163
0.266768	0.262762	0.221768	0.210289	0.212742	0.254842	0.221444	0.232261	0.270199
0.5	0.5	0.61479	0.558527	0.55464	0.500533	0.502989	0.499998	0.508486
0.5	0.5	0.38521	0.440252	0.445232	0.496954	0.496695	0.499996	0.491515
0.25	0.25	0.25	0.281098	0.25529	0.320188	0.274109	0.28057	0.295486
0.25	0.25	0.25	0.281033	0.255116	0.318449	0.268738	0.279632	0.295482
0.25	0.25	0.25	0.156879	0.233708	0.042208	0.187096	0.160799	0.113226
0.25	0.25	0.25	0.281032	0.255234	0.319378	0.270058	0.279659	0.295482
0.540273	0.5	0.5	0.504994	0.527244	0.515907	0.514293	0.500834	0.521943
0.459727	0.5	0.5	0.494617	0.472669	0.484094	0.485745	0.498362	0.478006
0.293067	0.278447	0.593738	0.153311	0.092969	0.309321	0.2881	0.406093	0.372131
0.706933	0.721553	0.406262	0.850034	0.907063	0.690429	0.712174	0.593977	0.627873
0.29739	0.445044	0.408407	0.361806	0.365843	0.341436	0.376036	0.159668	0.315455
0.70261	0.554956	0.591593	0.637976	0.634592	0.658599	0.624035	0.84027	0.684641
0.606784	0.731206	0.716173	0.995916	0.991331	0.948368	0.939435	0.97076	0.933381
0.393216	0.268794	0.283827	0.003951	0.00851	0.051675	0.060884	0.029249	0.066621
0.461278	0.342686	0.357333	0.140877	0.127193	0.153092	0.164928	0.195024	0.163887
0.538722	0.657314	0.642667	0.86253	0.874057	0.848984	0.835384	0.804869	0.836866
0.470491	0.521664	0.423961	0.379304	0.457352	0.475896	0.372411	0.469517	0.461001
0.529509	0.478336	0.576039	0.619947	0.541864	0.524037	0.627507	0.530381	0.539539
0.470491	0.521664	0.423961	0.378964	0.457662	0.475049	0.372403	0.467649	0.460666
0.664206	0.485032	0.287992	0.121655	0.241752	0.159833	0.144201	0.110223	0.113522
0.655636	0.659726	0.870108	0.75955	0.708472	0.779783	0.70181	0.781963	0.595449
0.344364	0.340274	0.129892	0.240488	0.29041	0.220729	0.298013	0.218117	0.404521
0.695276	0.456289	0.212347	0.401851	0.231906	0.28349	0.302842	0.066388	0.220862
0.601117	0.097369	0.636739	0.40696	0.269312	0.210694	0.420666	0.606164	0.395409
0.353301	0.204674	0.026644	0.300221	0.066878	0.055827	0.031449	0.169908	0.063071
0.636898	0.795326	0.440299	0.404342	0.510805	0.641258	0.50827	0.546003	0.815791
0.009801	0	0.533057	0.297558	0.425631	0.297929	0.459931	0.282283	0.121144

16	17	18	19	20	21	22	23	24
0.055581	0.043707	0.015816	0.013637	0.004381	0.044006	0.028698	0.024597	0.018179
0.023539	0.033061	0.015753	0.01171	0.005436	0.028533	0.014351	0.013468	0.020985
0.015472	0.027504	0.011738	0.0078	0.009748	0.030663	0.007281	0.015052	0.030575
0.021241	0.025434	0.002453	0.012238	0.007957	0.037986	0.020479	0.013681	0.028164
0.075114	0.091931	0.005529	0.024422	0.028724	0.061546	0.089726	0.033769	0.069187
0.14537	0.117128	0.178379	0.160863	0.208885	0.149829	0.163643	0.16732	0.153459
0.012551	0.029121	0.01753	0.016699	0.000271	0.008396	0.002667	0.003127	0.007143
0.035276	0.008934	0.027956	0.027202	0.029899	0.020994	0.025628	0.038394	0.019823
0.01054	0.019276	0.024992	0.017268	0.025311	0.005791	0.003927	0.000627	0.000748
0.001213	0.03291	0.063293	0.023941	0.067568	0.061584	0.033902	0.044394	0.07971
0.107456	0.086164	0.08013	0.108198	0.079807	0.069567	0.103065	0.087628	0.058665
0.128886	0.030358	0.038039	0.140691	0.093506	0.077497	0.057027	0.170417	0.12709
0.06967	0.061752	0.095371	0.077834	0.101587	0.076633	0.062675	0.0789	0.081865
0.084309	0.084508	0.100432	0.099645	0.10255	0.081505	0.102997	0.091519	0.076216
0.046589	0.081551	0.088932	0.055777	0.054969	0.055746	0.042046	0.05015	0.052037
0.042179	0.064848	0.040036	0.013217	0.016831	0.038916	0.00172	0.018086	0.036119
0.079326	0.075594	0.110157	0.08513	0.092065	0.082579	0.068273	0.08112	0.074318
0.023025	0.0262	0.018739	0.040148	0.015296	0.029088	0.04226	0.026964	0.026271
7912	7934	7532	7460	7112	7416	7444	7170	7306
0.200778	0.237747	0.059803	0.073326	0.073363	0.217352	0.220457	0.101812	0.196642
0.593396	0.469276	0.624887	0.673608	0.708789	0.555259	0.557199	0.681669	0.60327
0.205376	0.294749	0.311869	0.252507	0.217833	0.226186	0.222153	0.216336	0.200661
0.518829	0.505659	0.866568	0.500058	0.499999	0.539825	0.500111	0.533179	0.504861
0.480024	0.494201	0.133352	0.499758	0.499999	0.457906	0.5	0.466058	0.494992
0.266131	0.312137	0.312999	0.263645	0.295073	0.284932	0.298589	0.25	0.266253
0.259423	0.311998	0.31286	0.263534	0.285528	0.284777	0.297813	0.25	0.262446
0.217202	0.06469	0.060873	0.208861	0.131924	0.139569	0.102347	0.25	0.210668
0.259477	0.31203	0.312926	0.263562	0.287965	0.284826	0.297924	0.249999	0.262495
0.501634	0.654446	0.584451	0.50381	0.507139	0.507396	0.50132	0.500715	0.499994
0.498361	0.345394	0.413326	0.496299	0.492861	0.493075	0.497575	0.499376	0.499987
0.533557	0.363563	0.30519	0.371925	0.119424	0.375057	0.26029	0.45311	0.183117
0.466434	0.636451	0.694404	0.627093	0.87628	0.623966	0.743986	0.54689	0.818991
0.220397	0.216466	0.307571	0.333966	0.216936	0.381664	0.185785	0.288316	0.289349
0.77937	0.782431	0.693252	0.666455	0.783073	0.61839	0.814005	0.711683	0.710808
0.920521	0.799625	0.91201	0.905795	0.99876	0.94702	0.983586	0.981823	0.955404
0.079478	0.198809	0.089626	0.094028	0.001294	0.053068	0.01603	0.018349	0.044471
0.229152	0.061018	0.142995	0.153234	0.147738	0.13277	0.154443	0.225293	0.125202
0.771219	0.940986	0.858567	0.844387	0.853194	0.86742	0.847651	0.776893	0.876852
0.452485	0.421721	0.487722	0.438411	0.497717	0.48455	0.377556	0.462984	0.51697
0.54756	0.57713	0.513606	0.56126	0.502435	0.515359	0.620451	0.53703	0.481294
0.452214	0.422771	0.487907	0.438446	0.497586	0.485737	0.377535	0.462968	0.51866
0.409416	0.336178	0.219651	0.103893	0.152355	0.339091	0.015448	0.166964	0.360007
0.775039	0.742543	0.85457	0.67931	0.857523	0.740439	0.617648	0.750879	0.740749
0.224964	0.257358	0.145371	0.320363	0.142477	0.26082	0.382312	0.249589	0.261856
0.484451	0.432096	0.437746	0.50929	0.169123	0.389732	0.17496	0.453668	0.258102
0.318429	0.359462	0.326187	0.339234	0.303266	0.418825	0.088762	0.507002	0.376045
0.088777	0.139909	0.148895	0.115202	0.146587	0.042221	0.027915	0.004738	0.00539
0.905113	0.625408	0.477386	0.721827	0.462197	0.507197	0.732725	0.661867	0.422569
0.010214	0.23887	0.377078	0.159719	0.391317	0.448989	0.241023	0.335314	0.574162

25	26	27	28	29	30	31	32	33
0.019101	0.012853	0.030557	0.005685	0.042177	0.023096	0.063212	0.052603	0.033707
0.014811	0.010386	0.035306	0.00376	0.026735	0.017483	0.015997	0.039928	0.048239
0.022726	0.012472	0.039695	0.007008	0.042615	0.020408	0.022346	0.0433	0.052175
0.036557	0.012131	0.023773	0.003846	0.06071	0.042784	0.053303	0.044074	0.039195
0.056972	0.030707	0.069993	0.010065	0.052324	0.052745	0.050465	0.100103	0.086151
0.15899	0.165425	0.103745	0.234225	0.087988	0.165686	0.142856	0.055346	0.082014
0.006963	0.008227	0.05249	0.004899	0.050894	0.010569	0.003226	0.049258	0.04264
0.019291	0.03032	0.06356	0.013423	0.026896	0.02941	0.030898	0.0033	0.032007
0.001672	0.017241	0	0.005032	0	0.005818	0.022765	0.013817	0.033031
0.070449	0.02763	0.031341	0.198065	0.032468	0.049297	0.008412	0.018477	0.003374
0.073994	0.097681	0.061333	0.019659	0.079519	0.092291	0.084007	0.069129	0.056242
0.123232	0.156663	0.156235	0.217008	0.097911	0.088059	0.146083	0.094285	0.124654
0.078575	0.083507	0.066021	0.021048	0.037155	0.089282	0.060443	0.048646	0.06098
0.087071	0.089824	0.090214	0.216982	0.101727	0.086909	0.08564	0.055958	0.063674
0.045305	0.05759	0.039623	0.001434	0.04187	0.049082	0.043329	0.086165	0.061352
0.027977	0.017429	0.044167	0.001122	0.045413	0.037002	0.075033	0.099823	0.096288
0.079362	0.0837	0.062321	0.014872	0.043588	0.082095	0.078352	0.064731	0.072267
0.015502	0.035038	0.031445	0.000836	0.042628	0.015058	0.02506	0.044591	0.053012
7152	7374	8452	6538	8344	7296	8074	8460	8808
0.187647	0.085509	0.187531	0.027921	0.24272	0.191151	0.207537	0.295946	0.250692
0.62137	0.676672	0.624938	0.935583	0.514559	0.616646	0.58433	0.408097	0.498617
0.189993	0.238267	0.187531	0.031914	0.24272	0.193679	0.208133	0.295957	0.250692
0.500192	0.500009	0.5	0.50286	0.534303	0.500041	0.5	0.512816	0.5
0.498568	0.499996	0.5	0.497872	0.465697	0.499986	0.5	0.487174	0.5
0.267128	0.256597	0.25	0.255758	0.269906	0.285717	0.25	0.256323	0.25
0.266865	0.255752	0.25	0.252835	0.269906	0.285637	0.25	0.256323	0.25
0.198323	0.23152	0.25	0.23195	0.190281	0.142804	0.25	0.231035	0.25
0.267131	0.256212	0.25	0.25446	0.269906	0.28566	0.25	0.256322	0.25
0.500673	0.501592	0.5	0.50708	0.644792	0.500003	0.50314	0.626041	0.500269
0.499109	0.498385	0.5	0.492144	0.355208	0.499994	0.49686	0.369384	0.499731
0.203508	0.300623	0.325889	0.404945	0.325226	0.241633	0.609163	0.346607	0.268916
0.794606	0.699325	0.674111	0.595912	0.674774	0.758413	0.390837	0.653394	0.731084
0.390755	0.28374	0.253535	0.276651	0.537097	0.447664	0.513676	0.305692	0.312694
0.608972	0.71821	0.746465	0.724056	0.462903	0.551885	0.486324	0.694308	0.687306
0.957858	0.952735	0.664031	0.978862	0.633544	0.940402	0.977916	0.529099	0.657934
0.041947	0.047381	0.335969	0.020472	0.366456	0.059989	0.022084	0.470901	0.342066
0.116334	0.175199	0.406824	0.056743	0.193659	0.16697	0.211511	0.031543	0.256768
0.884234	0.824748	0.593176	0.939925	0.806341	0.833022	0.788489	0.969574	0.743232
0.473382	0.481667	0.422573	0.088411	0.267531	0.50685	0.413757	0.465049	0.489197
0.524563	0.518098	0.577427	0.911426	0.732469	0.493374	0.586243	0.534951	0.510803
0.476268	0.48187	0.422573	0.088592	0.267531	0.506838	0.413757	0.465048	0.489197
0.294104	0.145834	0.471036	0.069347	0.290172	0.382098	0.716511	0.538764	0.767763
0.836905	0.70485	0.664645	0.946883	0.505564	0.847757	0.757667	0.592118	0.576849
0.163473	0.295065	0.335355	0.053216	0.494436	0.155501	0.242333	0.407883	0.423151
0.198593	0.347357	0.558571	0.449381	0.30551	0.241169	0.39444	0.40265	0.526406
0.30472	0.417135	0.628	0.83757	0.486974	0.281523	0.550989	0.436659	0.569357
0.011401	0.120794	0	0.022634	0	0.039652	0.197639	0.136231	0.356528
0.504645	0.684375	0.661812	0.088419	0.710074	0.629001	0.729327	0.681597	0.607059
0.480472	0.193581	0.338188	0.890828	0.289926	0.335983	0.073034	0.182175	0.036413

34	35	36	37	38	39	40	41	42
0.068413	0.024624	0.029754	0.012686	0.035493	0.041048	0.043239	0.014321	0.019589
0.0332	0.010688	0.030903	0.017964	0.021687	0.022559	0.018212	0.017087	0.017714
0.033219	0.007194	0.011926	0.013191	0.019773	0.012925	0.040148	0.012175	0.020236
0.043419	0.018311	0.027639	0.015081	0.022189	0.015465	0.007779	0.01811	0.026077
0.033951	0.066702	0.052877	0.027096	0.050936	0.073933	0.11163	0.034869	0.067939
0.170443	0.156759	0.13327	0.17797	0.154294	0.145111	0.113157	0.181361	0.182608
0	0.008054	0.010704	0.016477	0.020038	0.015511	0.044769	0.021944	2E-05
0.042865	0.02473	0.022391	0.024869	0.02603	0.020221	0.015234	0.033108	0.027621
0.03409	0.000544	0.008812	0.013033	0.007276	0.001175	0.005657	0.026642	0.005979
0.024216	0.08291	0.027118	0.054319	0.013632	0.041633	0.028549	0.024787	0.0597
0.069273	0.053936	0.083486	0.103048	0.126707	0.096763	0.092647	0.104341	0.080637
0.031152	0.162088	0.117766	0.045743	0.060831	0.07493	0.063878	0.040836	0.046992
0.067368	0.077652	0.074175	0.082876	0.077406	0.083366	0.046671	0.088322	0.080281
0.103075	0.083565	0.067857	0.111484	0.096173	0.077438	0.095417	0.100621	0.095705
0.045209	0.042523	0.083195	0.064605	0.062084	0.069441	0.040567	0.060833	0.052281
0.093033	0.021035	0.041145	0.020509	0.026858	0.032473	0.085941	0.025121	0.018048
0.101336	0.079177	0.079992	0.096232	0.084606	0.09049	0.083193	0.08708	0.089292
0.013043	0.008996	0.045358	0.037532	0.04329	0.042491	0.040312	0.043277	0.02336
8320	7026	7802	7276	7570	7474	8094	7424	7132
0.228759	0.171584	0.16923	0.085135	0.149346	0.178402	0.24701	0.11731	0.193771
0.542482	0.650875	0.545068	0.629249	0.583521	0.55532	0.505979	0.621998	0.579018
0.228759	0.176911	0.285818	0.285487	0.267116	0.266567	0.24701	0.26066	0.227211
0.661782	0.504464	0.523785	0.504501	0.508253	0.500008	0.516587	0.550385	0.514289
0.338218	0.495454	0.475778	0.495273	0.489636	0.500006	0.483413	0.451467	0.485629
0.314192	0.253162	0.26412	0.308896	0.298753	0.28924	0.312121	0.326806	0.315413
0.314192	0.249062	0.259706	0.308643	0.297401	0.287638	0.280817	0.302427	0.300251
0.057425	0.24903	0.216056	0.072695	0.104248	0.134931	0.126246	0.065653	0.081159
0.314192	0.249066	0.2605	0.308843	0.297473	0.288595	0.280817	0.303881	0.303921
0.5	0.501799	0.558087	0.531599	0.521189	0.500627	0.5	0.499998	0.504271
0.5	0.498317	0.438608	0.468381	0.479038	0.4994	0.5	0.499999	0.495744
0.451902	0.284483	0.335676	0.295372	0.46759	0.460171	0.338855	0.221812	0.196566
0.548098	0.714531	0.663358	0.704603	0.532439	0.539842	0.661145	0.778354	0.803468
0.561187	0.215391	0.343271	0.357654	0.303445	0.173376	0.065142	0.341946	0.27712
0.438813	0.784621	0.656727	0.642607	0.696563	0.828827	0.934858	0.658385	0.721981
1	0.951341	0.925717	0.915614	0.885076	0.903436	0.716519	0.892203	0.99988
0	0.048881	0.074352	0.084771	0.114942	0.096569	0.283481	0.107954	0.000109
0.251488	0.152552	0.158179	0.128051	0.149993	0.126595	0.107218	0.176006	0.158879
0.748512	0.847467	0.841837	0.872184	0.850121	0.875901	0.892782	0.823699	0.84148
0.395252	0.479005	0.522395	0.426451	0.445936	0.520183	0.328467	0.467279	0.456205
0.604748	0.51548	0.477896	0.573656	0.55405	0.483194	0.671533	0.532348	0.54385
0.395252	0.479	0.521561	0.425689	0.445949	0.520353	0.328467	0.466762	0.456297
0.813371	0.236956	0.257945	0.135139	0.19292	0.243331	0.695849	0.192748	0.157518
0.885964	0.898128	0.638085	0.719672	0.661199	0.679745	0.673597	0.66815	0.792729
0.114036	0.102039	0.361817	0.280682	0.33831	0.319186	0.326403	0.332055	0.207393
0.400111	0.172805	0.525555	0.593576	0.536608	0.468472	0.215869	0.340002	0.221231
0.400344	0.116318	0.202825	0.435878	0.489261	0.268393	0.475896	0.242265	0.252733
0.267204	0.003959	0.073943	0.076942	0.049319	0.008402	0.044595	0.171945	0.040873
0.542982	0.3926	0.70057	0.608347	0.858856	0.691613	0.730347	0.673403	0.551206
0.189814	0.603506	0.227558	0.320676	0.092401	0.297573	0.225058	0.159972	0.408087

43	44	45	46	47	48	49	50
0.045339	0.023279	0.030762	0.034218	0.026374	0.038239	0.03401	0.021475
0.029807	0.012094	0.024259	0.021468	0.005942	0.042379	0.02347	0.007783
0.029211	0.005799	0.024921	0.029482	0.022601	0.032706	0.024884	0.01141
0.02205	0.024306	0.021742	0.022231	0.031859	0.024676	0.022698	0.016151
0.081485	0.046626	0.068501	0.061918	0.0451	0.086111	0.070102	0.052084
0.144456	0.138591	0.171799	0.151129	0.143979	0.117932	0.143367	0.181464
0.008791	0.012491	0.004043	0.00915	0.015241	0.017799	0.015549	0.001666
0.025978	0.025831	0.021954	0.020892	0.013136	0.028874	0.02927	0.024743
0.000612	0.001522	0.011641	0.002128	0.000454	0.00072	0.008546	0.001233
0.046344	0.033141	0.044685	0.054057	0.054417	0.033209	0.034122	0.058942
0.079641	0.084002	0.097537	0.079264	0.0912	0.072808	0.086342	0.066501
0.089684	0.14082	0.047828	0.12388	0.150621	0.135597	0.063202	0.151256
0.075733	0.070118	0.076711	0.07402	0.068828	0.056458	0.078737	0.071926
0.076921	0.080237	0.098913	0.082287	0.090244	0.079268	0.079544	0.0799
0.060079	0.048863	0.054577	0.057497	0.047016	0.047582	0.067729	0.044102
0.057025	0.02023	0.028503	0.030757	0.012684	0.049733	0.032094	0.016287
0.078333	0.076871	0.091718	0.071154	0.075273	0.06079	0.082092	0.07029
0.039637	0.026848	0.02717	0.041516	0.033087	0.053579	0.054061	0.01822
7598	7272	7350	7466	7336	7988	7586	7058
0.208676	0.205406	0.180499	0.168502	0.155261	0.228586	0.189015	0.181238
0.548145	0.586353	0.574434	0.596447	0.627334	0.542669	0.538679	0.636973
0.239065	0.208533	0.244158	0.234122	0.217049	0.228757	0.272306	0.181594
0.50383	0.657573	0.500001	0.500394	0.504337	0.515353	0.509014	0.620111
0.496151	0.345326	0.499929	0.499607	0.495663	0.484642	0.490986	0.376614
0.279575	0.257663	0.305754	0.268732	0.253788	0.250127	0.295009	0.286794
0.278345	0.246215	0.305456	0.261474	0.252639	0.249883	0.293832	0.237461
0.163613	0.240163	0.08326	0.207696	0.240096	0.249871	0.117327	0.237461
0.278492	0.256385	0.305747	0.262087	0.253568	0.250121	0.293832	0.238507
0.506562	0.502542	0.51321	0.518736	0.500645	0.499991	0.500001	0.513477
0.493454	0.497436	0.48694	0.481266	0.499213	0.499993	0.5	0.48688
0.431234	0.172346	0.34085	0.405831	0.336821	0.324599	0.35349	0.19108
0.568761	0.827247	0.659966	0.594919	0.663157	0.675269	0.64651	0.807983
0.212974	0.342664	0.240945	0.264074	0.413983	0.222742	0.244584	0.236615
0.787025	0.657338	0.759125	0.735498	0.586042	0.777303	0.75538	0.763065
0.942631	0.917323	0.978157	0.942879	0.904332	0.868833	0.90216	0.993342
0.057363	0.082677	0.023021	0.057087	0.095729	0.131128	0.097846	0.00912
0.170267	0.178925	0.125118	0.133963	0.082885	0.212929	0.184926	0.163581
0.829739	0.821048	0.875411	0.868214	0.921443	0.78708	0.815074	0.836418
0.49611	0.466417	0.436773	0.473514	0.432688	0.415949	0.497451	0.473437
0.503891	0.533734	0.563186	0.526398	0.567315	0.584002	0.50255	0.525923
0.496109	0.466262	0.435556	0.473433	0.432673	0.416017	0.49745	0.472972
0.470891	0.193041	0.22747	0.253255	0.116724	0.434816	0.235721	0.174671
0.664019	0.741059	0.771452	0.631502	0.694698	0.531491	0.60294	0.795005
0.336	0.258821	0.228525	0.368459	0.305359	0.468444	0.397058	0.206079
0.498463	0.108234	0.407298	0.427974	0.114428	0.532748	0.37732	0.085707
0.4885	0.051896	0.418404	0.587747	0.435247	0.411152	0.400061	0.125653
0.004831	0.012837	0.075788	0.015717	0.003109	0.006742	0.066244	0.009743
0.629095	0.708678	0.634995	0.585399	0.624492	0.682165	0.669264	0.525645
0.366076	0.279594	0.290909	0.399233	0.372619	0.311142	0.264491	0.465898

Appendix D

This appendix contains the data on the measures for the second MILCON example:

Force Structure	Consolidation	Footprint Reduction	Joint Use	Payback	Deficit IRR	Restoration and Modernization IRR	Design Build	Years to IOC	Mission Panel Points	Installation CC Priority Points	Corrects ATFP Deficiency	Direct Support	Warfighting Enabler	Avg Facility Class	Eliminates Safety	Support Facility	Base Population
0.00	1.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00	0.04	0.50	0.00	1.00	0.00	0.53	0.00	1.00	0.80
1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00	0.37	0.00	0.00	1.00
1.00	1.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.50	1.00	0.00	0.00	1.00	0.69	0.00	0.00	0.50
0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.20	1.00	0.00	1.00	0.00	0.70	0.00	0.00	1.00
1.00	1.00	1.00	0.00	0.00	0.00	0.30	0.00	1.00	0.17	1.00	0.00	1.00	0.00	0.90	0.00	0.00	0.00
0.00	1.00	0.70	0.00	0.00	0.00	0.80	1.00	1.00	0.50	1.00	0.00	1.00	0.00	0.79	0.00	0.00	1.00
1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.33	1.00	0.00	1.00	0.00	0.29	0.00	0.00	1.00
0.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00	0.30	0.00	0.00	0.80
1.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.06	0.33	0.00	0.00	0.00	0.94	0.00	1.00	0.80
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	1.00	0.00	1.00	0.00	1.00	0.00	0.00	0.80
0.00	1.00	0.00	1.00	0.00	0.00	0.80	0.00	0.00	0.25	1.00	0.00	0.00	0.00	0.94	0.00	1.00	0.30
0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.00	0.84	0.00	1.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.25	1.00	0.00	1.00	0.00	0.70	0.00	0.00	1.00
1.00	1.00	0.00	0.00	0.00	0.80	0.00	1.00	1.00	0.11	0.50	0.00	0.00	0.00	0.52	0.00	1.00	1.00
0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.04	1.00	0.00	1.00	0.00	0.60	0.00	0.00	0.00
0.00	1.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.08	1.00	0.00	0.00	0.00	0.81	0.00	1.00	0.30
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.07	0.25	0.00	1.00	0.00	1.00	0.00	0.00	1.00
0.00	1.00	1.00	1.00	0.00	0.00	0.80	1.00	0.00	1.00	1.00	0.00	0.00	0.00	0.37	0.00	1.00	0.30
0.00	1.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.08	1.00	0.00	1.00	0.00	0.62	0.00	0.00	1.00
0.00	1.00	1.00	0.00	0.00	0.00	0.80	0.00	0.00	0.10	1.00	0.00	1.00	0.00	0.57	0.00	0.00	0.50
0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.04	1.00	0.00	0.00	0.00	0.70	0.00	1.00	0.00
0.00	0.00	0.00	0.00	1.00	0.00	0.80	0.00	0.00	0.02	1.00	0.00	1.00	0.00	0.67	0.00	0.00	0.30
0.00	1.00	0.70	0.00	0.00	0.00	1.00	1.00	0.00	0.04	0.50	0.00	1.00	0.00	0.47	0.00	0.00	1.00
0.00	1.00	1.00	0.00	0.00	0.00	0.80	0.00	0.00	0.08	1.00	0.00	0.00	0.00	0.71	0.00	1.00	0.80
0.00	1.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.33	1.00	0.00	1.00	0.00	0.40	0.00	0.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	1.00	0.00	0.00	0.00	0.94	0.00	1.00	0.80
0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00	1.00	0.70	0.00	0.00	0.80
0.00	0.00	0.70	0.00	0.00	0.00	1.00	1.00	0.00	0.02	0.25	0.00	1.00	0.00	0.69	0.00	0.00	0.80
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.03	0.25	0.00	1.00	0.00	0.84	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	1.00	0.00	1.00	0.00	0.81	0.00	0.00	1.00
0.00	1.00	0.70	0.00	0.00	0.00	1.00	0.00	1.00	0.17	0.50	0.00	0.00	0.00	0.64	0.00	1.00	0.80
0.00	1.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.14	1.00	0.00	0.00	0.00	0.69	0.00	1.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.02	0.50	0.00	1.00	0.00	0.77	0.00	0.00	1.00
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.05	0.25	1.00	0.00	0.00	0.90	0.00	1.00	1.00
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.08	1.00	0.00	1.00	0.00	0.64	0.00	0.00	0.00
0.00	1.00	1.00	0.00	0.00	0.00	0.80	1.00	0.00	0.25	1.00	0.00	0.00	0.00	0.54	0.00	1.00	0.80
0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.63	0.00	1.00	1.00
0.00	1.00	1.00	0.00	0.00	0.00	0.80	1.00	0.00	0.20	1.00	0.00	0.00	0.00	0.61	0.00	1.00	0.30
0.00	0.00	0.00	0.00	1.00	0.00	0.80	1.00	0.00	0.50	1.00	0.00	0.00	0.00	0.63	0.00	1.00	0.30
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.50	1.00	0.00	1.00	0.00	0.67	0.00	0.00	0.00
0.00	1.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.50	0.50	0.00	1.00	0.00	0.37	0.00	0.00	0.80
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.02	0.33	0.00	1.00	0.00	0.77	0.00	0.00	1.00
0.00	1.00	0.70	0.00	0.00	0.00	0.80	1.00	0.00	0.08	1.00	0.00	0.00	0.00	0.64	0.00	1.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.03	1.00	0.00	1.00	0.00	0.43	0.00	0.00	0.80

0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.06	0.50	0.00	1.00	0.00	0.89	0.00	0.00	0.80
0.00	1.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.02	1.00	0.00	1.00	0.00	0.48	0.00	0.00	0.50
0.00	1.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.20	0.50	0.00	0.00	0.00	0.58	0.00	1.00	0.80
0.00	1.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.20	0.50	0.00	0.00	0.00	0.72	0.00	1.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.33	1.00	0.00	0.00	0.00	0.93	0.00	1.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.06	0.50	0.00	0.00	0.00	0.94	0.00	1.00	0.80
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.02	1.00	0.00	1.00	0.00	0.44	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.50	1.00	0.00	0.00	0.00	0.64	0.00	1.00	0.80
0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.08	0.50	0.00	0.00	0.00	0.61	0.00	1.00	0.80
0.00	1.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.02	1.00	0.00	0.00	0.00	0.55	0.00	1.00	0.00
0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.10	1.00	0.00	0.00	0.00	0.60	0.00	1.00	0.00
0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.03	0.50	0.00	0.00	0.00	0.67	0.00	1.00	0.50
0.00	1.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.03	1.00	0.00	1.00	0.00	0.24	0.00	0.00	0.50
0.00	1.00	1.00	0.00	0.00	0.00	0.30	0.00	0.00	0.03	1.00	0.00	0.00	0.00	1.00	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.05	0.33	0.00	0.00	0.00	1.00	0.00	1.00	0.30
1.00	0.00	0.70	0.00	0.00	0.00	0.30	0.00	0.00	0.03	0.50	0.00	1.00	0.00	0.48	0.00	0.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.04	1.00	0.00	1.00	0.00	0.38	0.00	0.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.51	0.00	1.00	0.80
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.03	0.50	0.00	1.00	0.00	0.45	0.00	0.00	1.00
0.00	0.00	0.70	1.00	1.00	0.00	0.30	1.00	0.00	0.13	0.50	0.00	0.00	0.00	0.53	0.00	1.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.05	1.00	0.00	0.00	0.00	0.72	0.00	1.00	0.50
0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.17	0.50	0.00	0.00	0.00	0.50	0.00	1.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.03	0.33	0.00	1.00	0.00	0.61	0.00	0.00	1.00
0.00	1.00	1.00	0.00	0.00	0.00	0.30	1.00	0.00	0.14	1.00	0.00	1.00	0.00	0.66	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.33	0.50	0.00	0.00	0.00	0.90	0.00	1.00	0.00
0.00	0.00	1.00	0.00	0.00	0.00	0.80	0.00	0.00	0.03	0.50	0.00	0.00	0.00	0.76	0.00	1.00	0.50
0.00	1.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.04	0.20	0.00	0.00	0.00	0.52	0.00	1.00	1.00
0.00	1.00	1.00	0.00	0.00	0.00	0.80	0.00	0.00	0.14	1.00	0.00	0.00	0.00	0.44	0.00	1.00	0.50
0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.44	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.50	0.00	1.00	0.00	0.87	0.00	0.00	0.00
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.03	0.50	0.00	1.00	0.00	0.36	0.00	0.00	1.00
0.00	1.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.07	1.00	0.00	0.00	0.00	0.60	0.00	1.00	0.00
0.00	1.00	1.00	0.00	0.00	0.00	0.30	0.00	0.00	0.07	1.00	0.00	0.00	0.00	0.87	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.07	0.33	0.00	1.00	0.00	0.75	0.00	0.00	0.80
0.00	0.00	1.00	0.00	0.00	0.00	0.80	0.00	0.00	0.01	0.20	0.00	1.00	0.00	0.55	0.00	0.00	0.80
0.00	1.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.33	0.00	1.00	0.00	0.50	0.00	0.00	0.50
0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.07	0.25	0.00	0.00	0.00	0.46	0.00	1.00	0.50
0.00	1.00	1.00	0.00	0.00	0.00	0.80	0.00	0.00	0.03	1.00	0.00	1.00	0.00	0.19	0.00	0.00	0.50
0.00	0.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.33	0.00	1.00	0.00	0.61	0.00	0.00	0.50
0.00	1.00	1.00	0.00	0.00	0.00	0.80	0.00	0.00	0.06	0.33	0.00	1.00	0.00	0.34	0.00	0.00	0.80
0.00	0.00	0.70	0.00	0.00	0.00	0.80	1.00	0.00	0.14	1.00	0.00	0.00	0.00	0.47	0.00	1.00	0.80
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.03	0.25	0.00	1.00	0.00	0.39	0.00	0.00	1.00
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.03	0.50	0.00	1.00	0.00	0.53	0.00	0.00	0.80
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.33	0.00	1.00	0.00	0.64	0.00	0.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.03	1.00	0.00	0.00	0.00	0.63	0.00	1.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.14	1.00	0.00	0.00	0.00	0.51	0.00	1.00	1.00
0.00	0.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.09	0.50	0.00	0.00	0.00	0.45	0.00	1.00	1.00
0.00	1.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00	0.04	0.25	0.00	0.00	0.00	0.40	0.00	1.00	0.30
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.03	0.17	0.00	1.00	0.00	0.39	0.00	0.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.25	0.50	0.00	1.00	0.00	0.48	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.33	0.00	1.00	0.00	0.69	0.00	0.00	0.80

0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.11	1.00	0.00	1.00	0.00	0.31	0.00	0.00	0.80
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.39	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.05	1.00	0.00	0.00	0.00	0.63	0.00	1.00	0.00
0.00	1.00	0.70	0.00	0.00	0.00	0.30	1.00	0.00	0.01	1.00	0.00	1.00	0.00	0.53	0.00	0.00	0.80
1.00	1.00	0.00	0.00	0.00	0.30	0.00	0.00	1.00	0.10	1.00	0.00	0.00	0.00	0.39	0.00	1.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.07	0.33	0.00	0.00	0.00	0.60	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.01	0.20	0.00	1.00	0.00	0.70	0.00	0.00	0.80
0.00	0.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.09	0.25	0.00	0.00	0.00	0.51	0.00	1.00	0.80
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.03	0.20	0.00	1.00	0.00	0.51	0.00	0.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.33	0.00	1.00	0.00	0.63	0.00	0.00	0.80
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.07	1.00	0.00	0.00	0.00	0.67	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.50	0.00	1.00	0.00	0.63	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.05	1.00	0.00	0.00	0.00	0.49	0.00	1.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.25	1.00	0.00	0.00	0.00	0.50	0.00	1.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.25	0.00	1.00	0.00	0.57	0.00	0.00	0.50
0.00	1.00	1.00	0.00	0.00	0.00	0.30	1.00	0.00	0.08	0.33	1.00	0.00	0.00	0.72	0.00	1.00	0.30
0.00	1.00	1.00	0.00	0.00	0.00	0.80	0.00	0.00	0.03	0.33	0.00	0.00	0.00	0.49	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.03	1.00	0.00	1.00	0.00	0.84	0.00	0.00	0.80
0.00	1.00	1.00	0.00	0.00	0.00	0.30	0.00	0.00	0.06	1.00	0.00	0.00	0.00	0.81	0.00	1.00	0.00
0.00	0.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.33	0.00	0.00	0.00	0.69	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.14	1.00	0.00	0.00	0.00	0.72	0.00	1.00	0.00
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.03	0.50	0.00	0.00	0.00	0.66	0.00	1.00	0.50
0.00	1.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.06	0.20	0.00	0.00	0.00	0.49	0.00	1.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.02	1.00	0.00	0.00	0.00	0.55	0.00	1.00	0.00
0.00	1.00	0.70	0.00	0.00	0.00	1.00	0.00	0.00	0.04	1.00	0.00	1.00	0.00	0.03	0.00	0.00	0.00
0.00	1.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.50	0.00	1.00	0.00	0.27	0.00	0.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.08	0.50	0.00	0.00	0.00	0.47	0.00	1.00	0.50
0.00	0.00	0.70	0.00	0.00	0.00	0.30	0.00	0.00	0.02	1.00	0.00	1.00	0.00	0.69	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.20	0.00	1.00	0.00	0.67	0.00	0.00	0.50
0.00	0.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.08	0.50	0.00	0.00	0.00	0.69	0.00	1.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.13	1.00	0.00	1.00	0.00	0.42	0.00	0.00	0.30
0.00	1.00	0.00	0.00	0.00	0.00	0.30	1.00	0.00	0.11	0.33	0.00	1.00	0.00	0.75	0.00	0.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.06	0.25	0.00	1.00	0.00	0.55	0.00	0.00	0.80
1.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	1.00	0.02	0.33	0.00	0.00	0.00	0.13	0.00	1.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.07	1.00	0.00	1.00	0.00	0.22	0.00	0.00	0.30
0.00	1.00	1.00	1.00	0.00	0.00	0.30	0.00	0.00	0.05	1.00	0.00	0.00	0.00	0.31	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.04	0.25	0.00	0.00	0.00	0.57	0.00	1.00	0.80
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.05	0.25	0.00	0.00	0.00	0.66	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.03	0.33	0.00	0.00	0.00	0.85	0.00	1.00	0.00
0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	1.00	0.01	0.50	0.00	1.00	0.00	0.43	0.00	0.00	0.50
0.00	0.00	0.70	0.00	0.00	0.00	0.80	1.00	0.00	0.02	0.33	0.00	0.00	0.00	0.42	0.00	1.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.01	0.33	0.00	1.00	0.00	0.54	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	1.00	0.00	1.00	0.00	0.31	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.05	0.50	0.00	1.00	0.00	0.46	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	1.00	0.00	0.20	0.50	0.00	0.00	0.00	0.63	0.00	1.00	0.30
0.00	0.00	0.70	0.00	0.00	0.00	0.30	0.00	0.00	0.05	1.00	0.00	1.00	0.00	0.61	0.00	0.00	0.30
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.02	0.20	0.00	1.00	0.00	0.25	0.00	0.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	0.30	1.00	0.00	0.05	0.20	0.00	0.00	0.00	0.93	0.00	1.00	1.00
0.00	1.00	0.00	0.00	0.00	0.00	0.30	1.00	0.00	0.01	1.00	0.00	0.00	0.00	0.67	0.00	1.00	1.00
0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.33	0.25	0.00	0.00	1.00	0.42	0.00	0.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.03	0.25	0.00	1.00	0.00	0.31	0.00	0.00	1.00

0.00	1.00	0.70	0.00	0.00	0.00	0.30	0.00	0.00	0.02	0.50	0.00	1.00	0.00	0.59	0.00	0.00	0.50
0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.03	0.25	0.00	0.00	0.00	0.25	0.00	1.00	0.80
0.00	1.00	0.70	0.00	0.00	0.00	0.30	0.00	0.00	0.01	0.50	0.00	1.00	0.00	0.53	0.00	0.00	0.80
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.20	0.00	1.00	0.00	0.54	0.00	0.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.06	1.00	0.00	0.00	0.00	0.21	0.00	1.00	0.30
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.50	1.00	0.00	0.00	0.00	0.35	0.00	1.00	0.80
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.33	0.00	1.00	0.00	0.49	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.30	1.00	0.00	0.11	0.25	0.00	0.00	0.00	1.00	0.00	1.00	1.00
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.06	0.50	0.00	0.00	0.00	0.50	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.05	0.50	0.00	0.00	0.00	0.66	0.00	1.00	0.30
0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.03	0.50	0.00	1.00	0.00	0.10	0.00	0.00	0.50
0.00	1.00	0.70	0.00	0.00	0.00	0.00	1.00	0.00	0.04	1.00	0.00	0.00	0.00	0.72	0.00	1.00	1.00
0.00	1.00	0.70	0.00	0.00	0.00	0.80	1.00	0.00	0.04	0.50	0.00	0.00	0.00	0.26	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.01	0.17	0.00	1.00	0.00	0.52	0.00	0.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.13	1.00	1.00	0.00	0.00	0.60	0.00	1.00	1.00
1.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	1.00	0.01	0.33	0.00	0.00	0.00	0.49	0.00	1.00	0.50
0.00	0.00	0.00	1.00	0.00	0.00	0.30	1.00	0.00	0.10	0.33	0.00	1.00	0.00	0.41	0.00	0.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.09	0.50	0.00	0.00	0.00	0.60	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.03	0.50	0.00	0.00	0.00	0.64	0.00	1.00	0.30
0.00	0.00	0.00	0.00	1.00	0.00	0.80	0.00	0.00	0.25	0.50	0.00	0.00	0.00	0.19	0.00	1.00	0.80
0.00	0.00	0.70	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.50	0.00	0.00	0.00	0.43	0.00	1.00	0.50
0.00	1.00	1.00	0.00	0.00	0.00	0.30	0.00	0.00	0.04	0.50	0.00	0.00	0.00	0.56	0.00	1.00	1.00
0.00	1.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.01	0.50	0.00	1.00	0.00	0.69	0.00	0.00	0.50
0.00	0.00	1.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.20	0.00	1.00	0.00	0.12	0.00	0.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	0.80	1.00	0.00	0.04	0.33	0.00	0.00	0.00	0.50	0.00	1.00	0.80
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	1.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00
0.00	1.00	0.70	0.00	0.00	0.00	0.30	1.00	0.00	0.05	0.50	0.00	0.00	0.00	0.67	0.00	1.00	0.30
0.00	0.00	0.00	0.00	1.00	0.00	0.30	1.00	0.00	0.01	0.33	0.00	0.00	0.00	0.58	0.00	1.00	1.00
0.00	1.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.13	0.25	0.00	1.00	0.00	0.61	0.00	0.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.13	1.00	0.00	0.00	0.00	0.26	0.00	1.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.06	0.33	0.00	0.00	0.00	0.28	0.00	1.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.04	0.14	0.00	0.00	0.00	0.37	0.00	1.00	0.80
0.00	1.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.33	0.00	0.00	0.00	0.70	0.00	1.00	1.00
0.00	1.00	0.70	0.00	0.00	0.00	1.00	1.00	0.00	0.11	0.50	0.00	0.00	1.00	0.31	0.00	0.00	0.30
0.00	1.00	0.70	1.00	0.00	0.00	0.30	0.00	1.00	0.01	0.50	0.00	0.00	0.00	0.35	0.00	1.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.01	0.25	0.00	0.00	0.00	0.51	0.00	1.00	0.80
0.00	0.00	0.00	0.00	0.00	0.00	0.80	1.00	0.00	0.17	0.33	0.00	0.00	0.00	0.49	0.00	1.00	0.30
0.00	0.00	0.70	0.00	0.00	0.00	0.30	0.00	0.00	0.06	0.33	0.00	0.00	0.00	0.69	0.00	1.00	1.00
0.00	0.00	0.70	0.00	0.00	0.00	0.80	1.00	0.00	0.02	0.33	0.00	0.00	0.00	0.31	0.00	1.00	0.30
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.02	0.17	0.00	0.00	0.00	0.33	0.00	1.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.04	1.00	0.00	1.00	0.00	0.62	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.04	0.33	0.00	0.00	0.00	0.32	0.00	1.00	0.50
0.00	0.00	0.70	0.00	0.00	0.00	0.30	0.00	0.00	0.03	0.33	0.00	0.00	0.00	0.72	0.00	1.00	0.80
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.33	1.00	0.00	0.00	1.00	0.00	1.00	0.50
0.00	1.00	1.00	0.00	0.00	0.00	0.30	0.00	0.00	0.17	1.00	0.00	0.00	0.00	0.22	0.00	1.00	1.00
0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.05	0.50	0.00	0.00	0.00	0.87	0.00	1.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.04	1.00	0.00	0.00	0.00	0.57	0.00	1.00	0.50
0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.06	0.50	0.00	0.00	0.00	0.27	0.00	1.00	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.25	1.00	0.00	0.00	1.00	0.00	1.00	0.50
0.00	1.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.33	0.00	1.00	0.00	0.64	0.00	0.00	0.50

Appendix E

This appendix contains the output from the 50 runs on the MILCON example # 2:

	Known	1	2	3	4	5	6
Force Structure	0.072	0.096292	0.084003	0.088433	0.052029	0.049109	0.080281
Consolidation	0.0168	0.02149	0.020733	0.021197	0.021591	0.017689	0.018887
Foorprint Reduction	0.0312	0.038742	0.036681	0.035352	0.040162	0.037419	0.035594
Joint Use	0.04	0.050151	0.040359	0.053394	0.04502	0.039135	0.064375
Payback	0.04	0.058313	0.056889	0.074582	0.095567	0.048323	0.077083
Deficit IRR	0.1125	0.060537	0.065302	0.009342	0.033146	0.005258	0.052117
Rest. & Modern. IRR	0.1125	0.139992	0.126467	0.131821	0.142463	0.137845	0.129116
Design Build	0.0075	0.005305	0.005888	0.008792	0.00648	0.013079	0.004508
Years to IOC/Need date	0.00675	0.000319	0.002578	0.000256	0.025162	0.061351	0.002739
Mission Pannel Points	0.02025	0.00346	0.001533	7.85E-05	0.022813	0.001203	0.000972
Installation CC's Priority	0.0405	0.051218	0.043012	0.045828	0.050815	0.056504	0.050334
Corrects ATFP Deficiency	0.025	0.048352	0.036196	0.040035	0.0294	0.086622	0.04209
Direct Operational Support	0.1225	0.082949	0.083808	0.07501	0.080151	0.100034	0.091531
Warfighting Enablers	0.0525	0.026494	0.058388	0.059311	0.02485	0.039727	0.03299
Facility Age	0.126	0.159821	0.145146	0.146653	0.161857	0.146552	0.145938
Eliminates Safety Violation	0.054	0.040121	0.17382	0.104505	0.130468	0.065233	0.048541
Support Facility	0.096	0.051723	0.055344	0.044334	0.046911	0.06925	0.062727
Base Population	0.024	0.030612	0.020503	0.022052	0.031496	0.038001	0.033593
Error		870	1052	1250	1022	1486	1162
Difference in weights		**0.368075**	**0.365737**	**0.422832**	**0.479248**	**0.4364**	**0.325164**
Efficiencies		0.29175	0.252279	0.296965	0.292054	0.183343	0.293769
op suppt		0.416281	0.424898	0.372114	0.412875	0.505048	0.407914
QOL		0.294803	0.321968	0.329254	0.292373	0.311902	0.296034
operational		0.627298	0.614297	0.568014	0.516012	0.523854	0.512888
resources		0.372659	0.385634	0.431436	0.481961	0.476846	0.484388
readiness		0.48179	0.45045	0.37847	0.423458	0.283002	0.444268
responsiveness		0.144174	0.124508	0.147297	0.253813	0.26299	0.143061
security		0.116152	0.085187	0.107588	0.071209	0.171512	0.103183
missions		0.262809	0.33439	0.361003	0.254391	0.276983	0.304619
work QOL		0.715363	0.764543	0.798181	0.728942	0.657642	0.667506
sense of community		0.279379	0.235421	0.200713	0.268409	0.344164	0.326546
right place		0.526143	0.542042	0.524265	0.345239	0.511316	0.532821
right size		0.473924	0.456636	0.474753	0.652193	0.488539	0.467266
joint use		0.461276	0.414847	0.416748	0.319842	0.447632	0.452393
econ		0.536341	0.584756	0.582118	0.678941	0.552725	0.541697
reduce deficit		0.301839	0.341189	0.066333	0.189582	0.036787	0.287587
restore and mondernize		0.698006	0.660762	0.936001	0.814839	0.964425	0.71247
ability to execute		0.088399	0.111298	0.160405	0.061835	0.098468	0.077255
mission timing		0.915992	0.890764	0.840447	0.941272	0.898584	0.92281
combat capability		0.758197	0.589859	0.558387	0.763114	0.715093	0.736618
mission support		0.242167	0.410951	0.44152	0.236592	0.283989	0.265497
modern facilities		0.757835	0.589646	0.558032	0.75945	0.714468	0.738537
safe facil		0.190245	0.70613	0.397655	0.612171	0.318024	0.245648
support facilities		0.627995	0.730146	0.670861	0.597774	0.645115	0.648883
promotes community		0.37168	0.270499	0.333684	0.401354	0.354006	0.347506
Consolidation		0.247768	0.29297	0.264697	0.219668	0.376998	0.268267
Foorprint Reduction		0.446666	0.518329	0.441451	0.40862	0.797481	0.505569
Years to IOC/Need date		0.005805	0.054706	0.005558	0.255096	0.514032	0.050853
Installation CC's Priority		0.931664	0.912738	0.994841	0.515159	0.473419	0.934669
Mission Panel Points		0.062935	0.032523	0.001703	0.231275	0.010078	0.018054

7	8	9	10	11	12	13	14	15
0.06179	0.085585	0.058382	0.039258	0.073342	0.061236	0.082655	0.091257	0.050903
0.018573	0.01979	0.017852	0.016843	0.018249	0.01898	0.019319	0.020303	0.018962
0.03398	0.033876	0.034677	0.030502	0.035206	0.035512	0.034643	0.03748	0.034571
0.062296	0.055187	0.042725	0.043604	0.046342	0.059853	0.046093	0.048691	0.04207
0.063145	0.07057	0.059508	0.082057	0.050362	0.081839	0.078172	0.076126	0.050046
0.055206	0.075444	0.027122	0.094739	0.065965	0.054385	0.025967	0.04767	0.06375
0.122965	0.122776	0.12231	0.10947	0.127374	0.129542	0.12339	0.133586	0.124742
0.005375	0.004831	0.006058	0.011955	0.008483	0.006408	0.00704	0.006592	0.009103
0.001707	0.000183	0.030437	0.000396	0.002316	0.001561	0.002156	0.001994	0.029311
0.001904	0.000467	0.021455	0.000216	0.001844	0.001071	0.018111	0.000723	0.012498
0.045182	0.043296	0.046254	0.035762	0.045236	0.044927	0.043696	0.049113	0.043947
0.042311	0.048283	0.087262	0.038738	0.045083	0.042694	0.025726	0.04972	0.081432
0.089222	0.10806	0.07972	0.061939	0.080171	0.083439	0.088534	0.094336	0.051127
0.049679	0.031043	0.050428	0.07457	0.064644	0.046946	0.053194	0.032322	0.045689
0.136719	0.137781	0.133756	0.117352	0.141831	0.142643	0.142156	0.150311	0.138614
0.148811	0.064809	0.129736	0.16025	0.14275	0.083398	0.117805	0.114694	0.123344
0.061624	0.08113	0.050887	0.037272	0.051225	0.054055	0.059789	0.063561	0.022503
0.02709	0.026879	0.029768	0.018188	0.025905	0.023455	0.022213	0.03016	0.024507
1166	1024	1382	1646	924	1360	902	986	1278
0.354566	**0.243673**	**0.409143**	**0.411323**	**0.339285**	**0.334831**	**0.322041**	**0.390243**	**0.425677**
0.28232	0.278189	0.223468	0.256463	0.224749	0.28822	0.299287	0.287545	0.226224
0.415148	0.434869	0.472728	0.430362	0.444564	0.410983	0.386626	0.416485	0.464843
0.30141	0.28534	0.299216	0.313515	0.334641	0.300538	0.308743	0.295262	0.309302
0.548641	0.547319	0.53668	0.508375	0.56766	0.504323	0.581706	0.564853	0.590928
0.446317	0.452064	0.457826	0.491283	0.428328	0.491656	0.416556	0.433917	0.408252
0.429316	0.455795	0.316133	0.474479	0.435187	0.447627	0.385233	0.435205	0.405438
0.130015	0.112151	0.22106	0.112355	0.130182	0.131103	0.182043	0.13999	0.204974
0.101918	0.111028	0.184593	0.090014	0.101409	0.103882	0.066541	0.11938	0.175182
0.33462	0.319865	0.275438	0.317185	0.327267	0.317529	0.366542	0.304246	0.208292
0.706194	0.621595	0.729025	0.824922	0.769878	0.743562	0.736941	0.683445	0.84868
0.294245	0.378382	0.269579	0.176778	0.229922	0.257128	0.264525	0.317385	0.151273
0.398922	0.562104	0.486797	0.301104	0.574864	0.421286	0.474762	0.561854	0.380775
0.607099	0.441894	0.513379	0.698549	0.430176	0.584519	0.526336	0.438204	0.622186
0.494398	0.438833	0.417602	0.346077	0.481389	0.422375	0.369721	0.390243	0.455516
0.501134	0.56115	0.581645	0.651266	0.523153	0.577532	0.627036	0.610131	0.541879
0.309746	0.380624	0.181488	0.463959	0.34096	0.295621	0.174344	0.262998	0.338259
0.689927	0.619422	0.818428	0.536098	0.658372	0.704158	0.828451	0.737001	0.661886
0.099579	0.099046	0.057975	0.247244	0.146581	0.11892	0.100021	0.113062	0.095538
0.901178	0.89997	0.942114	0.751103	0.848986	0.881196	0.905458	0.888544	0.901778
0.64227	0.776853	0.612253	0.453749	0.551041	0.639385	0.624735	0.744481	0.528048
0.357619	0.223171	0.387292	0.546283	0.444316	0.359739	0.375363	0.255075	0.471882
0.642316	0.776818	0.61318	0.453752	0.550514	0.638312	0.624792	0.744867	0.528055
0.699123	0.365395	0.59475	0.619622	0.554082	0.373196	0.517766	0.568367	0.469884
0.694839	0.751429	0.630859	0.672504	0.66576	0.699494	0.732076	0.678262	0.480941
0.305454	0.248957	0.369047	0.328175	0.336685	0.303517	0.271983	0.321837	0.523772
0.19751	0.294131	0.289946	0.184936	0.332509	0.223389	0.210832	0.285263	0.227971
0.361354	0.503493	0.56322	0.334911	0.641487	0.417965	0.378061	0.526602	0.415645
0.035095	0.004165	0.309152	0.010909	0.047137	0.032884	0.03383	0.038484	0.34113
0.92888	0.986402	0.469813	0.984679	0.920664	0.946228	0.685663	0.948037	0.511476
0.039151	0.010649	0.21792	0.005957	0.037537	0.022561	0.284193	0.013964	0.145463

16	17	18	19	20	21	22	23	24
0.060172	0.068823	0.100057	0.073692	0.06019	0.069987	0.075964	0.070563	0.083709
0.018113	0.016707	0.021578	0.022639	0.018313	0.019053	0.019324	0.018215	0.020625
0.034397	0.030989	0.038663	0.034582	0.036702	0.03475	0.037573	0.033804	0.037266
0.044459	0.046427	0.018583	0.054421	0.046163	0.048719	0.050678	0.043641	0.05269
0.081639	0.064537	0.081044	0.066681	0.056503	0.074673	0.087242	0.059627	0.063111
0.030198	0.042975	0.051872	0.025977	0.026313	0.05606	0.027509	0.051001	0.060425
0.127887	0.112808	0.142583	0.136281	0.129919	0.124007	0.134051	0.123311	0.131839
0.010177	0.007353	0.005306	0.000943	0.005684	0.006284	0.008509	0.005489	0.006474
0.026449	0.001637	0.000943	0.028138	0.031602	0.010665	0.00292	0.012564	0.000972
0.018695	0.017314	0.005015	0.031482	0.016923	0.019943	0.015101	0.019873	0.005797
0.04733	0.039994	0.052332	0.036361	0.050039	0.043256	0.047909	0.045848	0.047276
0.081567	0.063249	0.039897	0.096925	0.061105	0.042523	0.073167	0.071794	0.040397
0.104819	0.100703	0.089773	0.056192	0.12046	0.075906	0.102036	0.096317	0.075653
0.019362	0.049804	0.030102	0.046599	0.0296	0.043372	0.023172	0.048453	0.044149
0.140716	0.126226	0.160862	0.13459	0.135294	0.140036	0.149128	0.136717	0.149793
0.071896	0.061717	0.097297	0.138185	0.100464	0.138785	0.139378	0.179199	0.188947
0.074922	0.074693	0.057926	0.024626	0.091754	0.047378	0.071268	0.067447	0.045497
0.028932	0.023226	0.031361	0.024054	0.035759	0.024212	0.030045	0.027434	0.027474
1220	1050	1060	2032	1212	936	1096	996	896
0.356895	**0.205745**	**0.422152**	**0.513972**	**0.31744**	**0.348248**	**0.43196**	**0.35951**	**0.44016**
0.266071	0.272119	0.278062	0.246219	0.228635	0.283254	0.28263	0.224912	0.275172
0.46854	0.438589	0.419763	0.458898	0.47391	0.424971	0.434229	0.475176	0.412174
0.269549	0.287717	0.304233	0.294883	0.294226	0.292018	0.283211	0.300982	0.31004
0.518943	0.586942	0.639572	0.508152	0.551269	0.558088	0.506444	0.539165	0.575721
0.476025	0.409091	0.360493	0.491848	0.45002	0.43606	0.48911	0.460097	0.421303
0.337489	0.353859	0.463246	0.353583	0.329857	0.423239	0.371892	0.367148	0.46617
0.21788	0.151103	0.150943	0.211212	0.220467	0.189232	0.17067	0.175816	0.145741
0.174087	0.14421	0.095047	0.211212	0.128939	0.10006	0.168499	0.151088	0.09801
0.264905	0.345296	0.28502	0.223994	0.316954	0.281482	0.288325	0.303368	0.290726
0.618145	0.659304	0.706111	0.834917	0.570425	0.756083	0.642357	0.684211	0.764346
0.387353	0.341907	0.293492	0.165083	0.435144	0.245017	0.358096	0.316105	0.235576
0.435788	0.430903	0.562621	0.588985	0.477552	0.44273	0.530714	0.581892	0.528393
0.563719	0.568885	0.437539	0.411015	0.522047	0.560484	0.470076	0.419204	0.476571
0.351019	0.41705	0.185391	0.449382	0.448667	0.394437	0.366602	0.421725	0.454493
0.644572	0.579739	0.808507	0.550618	0.549162	0.604561	0.631105	0.576205	0.544385
0.190971	0.276904	0.26676	0.160099	0.168322	0.311679	0.170346	0.292339	0.31448
0.80876	0.726863	0.73325	0.839901	0.831097	0.689444	0.830106	0.706814	0.68615
0.099691	0.110947	0.083741	0.009732	0.054399	0.078139	0.114816	0.065701	0.107779
0.900718	0.887871	0.916563	0.990268	0.944452	0.922145	0.885172	0.937643	0.897648
0.844505	0.664956	0.750357	0.546662	0.801959	0.634553	0.814995	0.668154	0.631341
0.155997	0.328864	0.251606	0.453338	0.197063	0.36258	0.185084	0.336121	0.368432
0.844534	0.66542	0.748815	0.546662	0.806116	0.634251	0.819732	0.663884	0.632099
0.431494	0.325352	0.452917	0.561266	0.598592	0.628585	0.766137	0.870175	0.797321
0.717572	0.75929	0.648738	0.505882	0.716655	0.662176	0.702724	0.708914	0.622924
0.277096	0.236099	0.351225	0.494118	0.279302	0.338397	0.296249	0.288353	0.376164
0.232714	0.18387	0.277304	0.440241	0.27832	0.215041	0.287193	0.358309	0.273186
0.441922	0.341064	0.496872	0.672484	0.557795	0.392208	0.558409	0.664977	0.493592
0.287646	0.027825	0.016241	0.293159	0.320255	0.143813	0.044506	0.160388	0.018024
0.514732	0.679703	0.901124	0.378837	0.50709	0.583303	0.730314	0.585287	0.876734
0.203318	0.294247	0.086352	0.328005	0.171501	0.268931	0.230204	0.25369	0.107501

25	26	27	28	29	30	31	32	33
0.05469	0.085792	0.060641	0.060345	0.078525	0.10187	0.063556	0.058898	0.06788
0.015037	0.020611	0.020939	0.020999	0.018465	0.020326	0.015093	0.019543	0.019296
0.027913	0.035662	0.035364	0.038183	0.03274	0.036204	0.028225	0.035767	0.036536
0.039473	0.058584	0.045971	0.037216	0.043354	0.037298	0.039696	0.044502	0.042338
0.038899	0.076942	0.051778	0.044345	0.063274	0.091304	0.093965	0.047275	0.054229
0.103389	0.066388	0.059129	0.026699	0.036644	0.053627	0.070233	0.120157	0.065886
0.101412	0.125418	0.129194	0.13186	0.121651	0.124603	0.102899	0.126682	0.129717
0.00539	0.004833	0.007367	0.002165	0.007452	0.004583	0.002807	0.01066	0.005045
0.006259	0.000371	0.027897	0.024617	0.00731	0.000437	0.002608	0.005059	0.005736
0.016365	0.000176	0.0237	0.017659	0.016817	0.000491	0.001715	0.002157	0.011848
0.036065	0.041648	0.040555	0.0524	0.042674	0.04436	0.037115	0.041615	0.04678
0.054934	0.022796	0.098838	0.078137	0.074009	0.028895	0.031431	0.056456	0.040124
0.137508	0.101634	0.068823	0.119461	0.077261	0.083343	0.094053	0.114939	0.060097
0.066428	0.041721	0.031045	0.021592	0.062612	0.055401	0.074739	0.026689	0.045375
0.112607	0.145811	0.144805	0.149488	0.134866	0.142633	0.114688	0.138791	0.146144
0.058859	0.0995	0.167912	0.09925	0.12013	0.095455	0.085344	0.108036	0.080588
0.114002	0.072292	0.038553	0.090284	0.049237	0.054636	0.070341	0.086198	0.031574
0.020953	0.023047	0.022176	0.039784	0.02651	0.023611	0.021957	0.023174	0.03038
626	1098	1346	1456	1260	1270	1234	954	920
0.153282	**0.290708**	**0.473221**	**0.35014**	**0.356209**	**0.342026**	**0.277493**	**0.22037**	**0.312693**
0.165803	0.292806	0.242118	0.22315	0.232929	0.284553	0.284197	0.213594	0.274595
0.530687	0.402662	0.486799	0.472991	0.446395	0.395752	0.420096	0.507632	0.411303
0.301445	0.302198	0.270738	0.308213	0.318757	0.314262	0.299634	0.28012	0.318569
0.520977	0.529776	0.594173	0.634878	0.541924	0.548493	0.530018	0.568971	0.651264
0.473502	0.465001	0.404163	0.365032	0.458025	0.451513	0.47003	0.429692	0.350881
0.385692	0.475891	0.386712	0.334806	0.354097	0.450021	0.412126	0.486986	0.474899
0.121071	0.115997	0.204261	0.204811	0.165943	0.125228	0.104876	0.11705	0.167775
0.103515	0.056614	0.203036	0.165197	0.165792	0.073014	0.074819	0.111215	0.097554
0.384265	0.356296	0.205066	0.298323	0.314897	0.350663	0.402543	0.278982	0.256385
0.552957	0.682592	0.776174	0.572519	0.762302	0.754337	0.693063	0.609982	0.80569
0.44708	0.313809	0.223464	0.42323	0.23773	0.248083	0.308232	0.390678	0.194162
0.633137	0.553061	0.421528	0.425944	0.622075	0.652696	0.421934	0.484643	0.379571
0.366758	0.446804	0.579083	0.578298	0.376177	0.348444	0.581751	0.515602	0.620693
0.502788	0.430272	0.46979	0.456875	0.406361	0.290306	0.297169	0.484882	0.439416
0.495479	0.565106	0.52913	0.544397	0.593077	0.710647	0.703431	0.515093	0.562835
0.50512	0.346452	0.314098	0.168595	0.231826	0.301109	0.405661	0.486054	0.33731
0.495459	0.654504	0.686287	0.832658	0.769614	0.699638	0.594338	0.512446	0.664102
0.083883	0.103483	0.074087	0.022347	0.100595	0.092481	0.063713	0.179408	0.073102
0.916501	0.90216	0.925912	0.980138	0.900756	0.91208	0.93893	0.820487	0.927807
0.674309	0.708416	0.689433	0.846618	0.549633	0.60056	0.556174	0.811603	0.569897
0.325748	0.290807	0.310993	0.153023	0.445418	0.399215	0.441961	0.188453	0.430286
0.675562	0.706869	0.689089	0.847159	0.555028	0.601677	0.552275	0.812267	0.56939
0.353112	0.482358	0.799049	0.562457	0.494384	0.402665	0.41097	0.632277	0.313978
0.845897	0.762312	0.637238	0.692125	0.649748	0.700796	0.761623	0.787656	0.510461
0.155471	0.24303	0.366541	0.304985	0.349839	0.302849	0.237736	0.211757	0.491153
0.474632	0.297383	0.251352	0.256309	0.388861	0.373758	0.172239	0.311881	0.173835
0.881091	0.514542	0.424506	0.466045	0.689487	0.66572	0.3221	0.570812	0.329148
0.106283	0.008806	0.303006	0.25926	0.109559	0.009677	0.06304	0.103762	0.089593
0.612449	0.988376	0.4405	0.551868	0.639551	0.981369	0.897207	0.853611	0.730663
0.277904	0.004185	0.257426	0.185982	0.25203	0.010854	0.041456	0.044243	0.18505

34	35	36	37	38	39	40	41	42
0.042497	0.062336	0.054755	0.078346	0.084789	0.075029	0.052752	0.114758	0.099455
0.018895	0.022409	0.019745	0.018231	0.021048	0.016716	0.015968	0.017747	0.019541
0.033833	0.038894	0.036674	0.032256	0.038887	0.030658	0.032693	0.033831	0.035999
0.046133	0.052131	0.014201	0.047906	0.048406	0.04938	0.026584	0.023857	0.048666
0.047421	0.063719	0.092151	0.064365	0.062857	0.06969	0.096475	0.047508	0.068146
0.019624	0.052631	0.031553	0.052168	0.063475	0.081708	0.056755	0.086944	0.075207
0.12319	0.149535	0.130841	0.122356	0.139522	0.113221	0.117876	0.122864	0.127816
0.00606	0.00291	0.005774	0.011665	0.007306	0.007452	0.006748	0.008743	0.004708
0.037546	0.009865	0.036099	0.000887	0.010207	0.00098	0.033869	0.039579	0.001231
0.020778	0.001641	0.024413	0.000157	0.021235	0.012489	0.01665	0.025748	0.001564
0.044738	0.059204	0.048761	0.039851	0.048369	0.038792	0.044192	0.043304	0.044794
0.107278	0.056996	0.10527	0.047176	0.081433	0.058737	0.053019	0.031889	0.016472
0.07707	0.082747	0.082782	0.109378	0.06484	0.122209	0.085916	0.083357	0.06511
0.032331	0.029088	0.034374	0.04677	0.022668	0.038623	0.043309	0.038595	0.044543
0.136949	0.160335	0.143833	0.139196	0.156558	0.119763	0.128041	0.135543	0.146683
0.11586	0.071046	0.054102	0.082765	0.136067	0.070954	0.094099	0.119076	0.036252
0.0481	0.053321	0.051482	0.081126	0.032303	0.095816	0.059588	0.054387	0.036813
0.0275	0.046411	0.028177	0.019489	0.026957	0.018489	0.03048	0.024396	0.025399
1396	1536	1512	1158	1030	1112	1256	958	1056
0.460442	**0.412372**	**0.451144**	**0.244437**	**0.467743**	**0.166317**	**0.346575**	**0.324845**	**0.328599**
0.259642	0.231532	0.212774	0.267451	0.264699	0.251858	0.257498	0.239576	0.309418
0.470447	0.446504	0.501968	0.432861	0.461765	0.47421	0.461083	0.484255	0.380507
0.269543	0.316191	0.282883	0.299603	0.27055	0.271249	0.282286	0.275869	0.31006
0.634058	0.499999	0.500079	0.579124	0.571884	0.526901	0.524035	0.698808	0.621505
0.360797	0.499958	0.499958	0.420958	0.421901	0.473277	0.476721	0.298377	0.377611
0.303121	0.452829	0.323665	0.403434	0.439521	0.411117	0.378857	0.433004	0.533001
0.232033	0.163425	0.228797	0.121545	0.188547	0.125772	0.220891	0.243441	0.136799
0.228033	0.12765	0.209715	0.108987	0.176352	0.123863	0.114989	0.065851	0.04329
0.232099	0.250577	0.233423	0.360398	0.189693	0.33954	0.27951	0.252414	0.288175
0.719528	0.683527	0.720323	0.662599	0.781432	0.580681	0.683085	0.714875	0.799232
0.280473	0.316433	0.281364	0.336216	0.219072	0.419404	0.320404	0.28558	0.200731
0.258138	0.538464	0.514593	0.505825	0.56012	0.565382	0.390932	0.68546	0.517177
0.745929	0.466283	0.485208	0.492344	0.440421	0.434609	0.603677	0.314496	0.48355
0.492467	0.450355	0.133499	0.425505	0.433444	0.414266	0.216561	0.333739	0.416523
0.506217	0.550462	0.866255	0.5717	0.562846	0.584657	0.785917	0.664596	0.583248
0.13761	0.260305	0.194212	0.298733	0.312753	0.419111	0.3249	0.414641	0.370824
0.863875	0.739574	0.805329	0.700659	0.687451	0.580751	0.674792	0.585947	0.630224
0.055518	0.039884	0.050279	0.22172	0.083914	0.12494	0.066254	0.074163	0.090449
0.944541	0.965433	0.949736	0.775651	0.916272	0.875623	0.933893	0.925862	0.913086
0.705829	0.739577	0.706506	0.70113	0.740242	0.758998	0.666649	0.681955	0.593787
0.2961	0.25998	0.29337	0.299806	0.258785	0.239876	0.336052	0.315749	0.40622
0.706128	0.741864	0.705868	0.70118	0.74052	0.760358	0.664028	0.687297	0.591918
0.597389	0.328724	0.265509	0.416915	0.643597	0.450478	0.488	0.6038	0.146289
0.63624	0.532928	0.64681	0.805365	0.545018	0.842239	0.658826	0.690345	0.591487
0.36376	0.463868	0.354018	0.193475	0.454817	0.162519	0.337001	0.309663	0.40809
0.153869	0.415144	0.382449	0.239075	0.315706	0.289834	0.196024	0.337054	0.210144
0.275514	0.720528	0.710345	0.422983	0.583281	0.531565	0.401342	0.642531	0.387127
0.364155	0.140034	0.330948	0.021738	0.127947	0.018768	0.356078	0.36262	0.025899
0.433908	0.840393	0.447038	0.976524	0.606319	0.742795	0.46461	0.396749	0.942468
0.201518	0.02329	0.223812	0.003853	0.266189	0.239146	0.17505	0.235896	0.032913

43	44	45	46	47	48	49	50	
0.031363	0.08288	0.09189	0.082319	0.049902	0.060525	0.085563	0.031542	
0.01731	0.019836	0.020714	0.016296	0.018662	0.01989	0.020518	0.019952	
0.033513	0.036444	0.040018	0.029233	0.036827	0.038355	0.035619	0.035678	
0.045761	0.049094	0.054336	0.049534	0.050952	0.042332	0.058929	0.04113	
0.04613	0.080053	0.051237	0.079362	0.059845	0.051835	0.062833	0.051395	
0.091786	0.093065	0.041047	0.060582	0.021251	0.014742	0.038695	0.065876	
0.119332	0.129426	0.140699	0.11574	0.129306	0.137861	0.123575	0.13163	
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0.051457	0.006219	0.000636	0.001053	0.029343	0.03749	0.000414	0.04304	
0.014205	0.002564	0.002965	0.00792	0.023954	0.010921	0.000268	0.02376	
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0.122007	0.148866	0.158319	0.126664	0.143134	0.155898	0.146486	0.145363	
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0.033822	0.028575	0.030022	0.025346	0.028062	0.034156	0.024877	0.028383	
1466	934	836	1102	1256	976	1118	1000	
0.365322	**0.348494**	**0.400156**	**0.186794**	**0.43644**	**0.36384**	**0.293984**	**0.481157**	
0.204715	0.295234	0.257604	0.273061	0.258867	0.205167	0.299158	0.187159	
0.533111	0.411255	0.396159	0.430491	0.42602	0.469732	0.393752	0.499344	
0.259882	0.295393	0.345551	0.295536	0.31531	0.325101	0.304662	0.313209	
0.55022	0.559483	0.590119	0.528018	0.571909	0.540755	0.590202	0.504523	
0.448804	0.43716	0.409857	0.471949	0.428046	0.459237	0.407264	0.493602	
0.396875	0.541023	0.458743	0.409493	0.353266	0.324712	0.411415	0.395306	
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0.222022	0.25627	0.307247	0.395029	0.243332	0.320766	0.385193	0.242908	
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0.380788	0.233525	0.196237	0.421386	0.173926	0.350942	0.383459	0.225755	
0.278442	0.501764	0.604471	0.570941	0.337068	0.545543	0.484604	0.33404	
0.721558	0.49836	0.395502	0.431039	0.663228	0.455166	0.520197	0.665834	
0.498074	0.380382	0.514638	0.384373	0.459827	0.449292	0.483675	0.445214	
0.502081	0.620256	0.485285	0.615829	0.540087	0.550144	0.515718	0.556335	
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0.56401	0.581694	0.774201	0.656558	0.859186	0.903838	0.762829	0.666839	
0.04201	0.080257	0.128562	0.233785	0.046062	0.060459	0.06275	0.070068	
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0.728779	0.519352	0.378629	0.456926	0.325822	0.432458	0.593683	0.81594	
0.659121	0.587057	0.555162	0.796915	0.488258	0.69734	0.78708	0.598533	
0.341774	0.414245	0.442733	0.203525	0.511701	0.299372	0.212939	0.401406	
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0.413444	0.841314	0.932656	0.81994	0.461478	0.5239	0.986944	0.413174	
0.127239	0.046424	0.054582	0.159508	0.241562	0.107384	0.005948	0.210913	

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Vita

David Thawley was born in Columbia, MO. He moved to St. Paul, MN in 1986 where he later graduated from Mounds View High School in 1997. He received his college education at the United States Air Force Academy where he was a four year intercollegiate tennis player. David was commissioned upon graduation from the Academy with a Bachelors of Science in Operations Research and a minor in Mathematics, in May, 2001. From the Academy, he directly entered into the Masters in Operations Research program at the Air Force Institute of Technology. After graduation from this Masters program in March of 2003, he moved on to Langley Air Force Base, VA where he is working as a scientific analyst.

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14. ABSTRACT

Deriving weights for a Value Focused Thinking (VFT) hierarchy demands considerable time and input from Decision Makers (DM) and Subject Matter Experts (SME). Often, the DMs and SMEs are the leaders of companies and organizations, and this required time is unrealistic with their schedules. In these situations, as well as scenarios where the are no available DMs / SMEs, conventional means of weighting a VFT hierarchy are impossible, and any VFT analysis is halted. When historical data exists on evaluation measures and performance of alternatives, linear programming and genetic algorithm based optimization may be used to derive historically optimal weights for a hierarchy. Analysis may then be done to determine the utility of transposing these weights into a hierarchy to evaluate a current list of alternatives. This type of analysis is also useful in "first cut" weighting of a hierarchy, and therefore reduces the time demands for DMs/SMEs to complete the weighting process. This methodology can provide insight into any situation where historical information exists on ordinally ranked, competing alternatives.

15. SUBJECT TERMS

Decision Analysis, Value Focused Thinking, Optimization, Linear Programming, Genetic Algorithm, Evolutionary Algorithm, Hierarchy, Weighting

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